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NOTES ON MINERALOGY:

DESIGNED FOR USE IN THE

ENGLISH HIGH SCHOOL, BOSTON.

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CHAPTER I.

INTRODUCTION.

DIVISIONS OF SCIENCE.

Science is classified knowledge, and is generally applied to external nature. It is divided into Natural and Physical Science.

Natural Science considers the external form and the internal structure of bodies.

Physical Science treats only of the matter of which these bodies are made up.

Geology, Mineralogy, Botany and Zoölogy should therefore be classed as Natural Sciences or departments of Natural History.

Physics and Chemistry, which treat of matter in reference to its molecular and atomic changes, as weight, hardness, color, combustibility, are Physical Sciences.

We give the following definitions from Prof. Niles, as containing much in few words: —

A body is anything we can see or feel.

Art is man's power to form.

Bodies formed by art are *artificial bodies.*

Bodies formed by nature are *natural bodies.*

Knowledge of natural bodies is *Natural History.*

Arrangement of parts is *structure.*

Bodies having structure are *structural bodies.*

Structural parts having different uses are *organs.*

Bodies having organs are *organic bodies.*

Natural bodies without organs are *inorganic bodies.*

Same structure is *homogeneous.*

A simple inorganic body having a homogeneous structure is *a mineral.*

Motions prompted by intelligence are *voluntary motions.*

An organic body giving signs of intelligence is *an animal.*

An organic body giving no signs of intelligence is *a plant.*

The science that treats of plants is called Botany.

The science that treats of animals is called Zoölogy.

The science that treats of minerals or mineral aggregates is called Mineralogy.

Botany and Zoölogy treat of all natural objects that have life.

Mineralogy treats of the inorganic world, or of natural objects that have not life.

CHAPTER II.

STRUCTURE OF MINERALS OR MODE OF CRYSTALLIZATION.

The structure of a mineral is the form it assumes in a solid state.

When a liquid passes to a solid state, crystallization or solidification occurs. The regular forms are called crystals and the structure is crystalline. The solid may be in a mass of imperfectly crystalline grains; the structure is then said to be massive, as in the case of marble.

Each mineral has a form peculiar to itself from which it rarely varies. These forms may vary by simple mathematical laws, but they are fundamentally the same. Crystals of quartz or beryl are essentially the same in all parts of the world. Common Salt has one form, Iceland Spar another. The rhombohedron will never taste saline.

FUNDAMENTAL FORMS OF CRYSTALS.

We find among the crystals of minerals a great variety of forms. By cleavage these are found to be only modifications of a few simple forms. The forms derived from these are called Secondary.

The primitive forms are arranged in Six Systems of crystallization.

First System.—Isometric.

Includes the Cube and Regular Octahedron.

The cube has its six faces equal squares and its angles all right angles.

The octahedron has eight faces equilateral triangles.

This system has three axes rectangular and equal.

Second System.—Tetragonal.

Includes the Right Prism with square base and the Tetragonal Pyramid.

The three axes are rectangular and two equal.

Third System.—Orthorhombic.

Includes the Right Prism with a rhombic base and the Rhombic Pyramid.

The three axes are rectangular and unequal.

Fourth System.—Monoclinic.

Includes the Inclined Rhombic Prism and the Monoclinic Pyramid.

Three axes are unequal, two are rectangular.

Fifth System.—Triclinic.

Includes the doubly inclined Rhomboidal Prism and the Triclinic Pyramid.

Three axes are unequal and unequally inclined.

Sixth System.—Hexagonal.

Includes the Hexagonal Prism, the Rhombohedron and the Hexagonal Pyramid.

Four axes. Three equal and equally inclined. One at right angles to the other three.

These forms and their secondaries could be more profitably studied by the use of models.

CLEAVAGE.

Galenite or calc spar may be readily separated in three directions. Mica may be split into thin elastic leaves. This property of naturally separating into layers is called cleavage. In many minerals this property is very distinct, in others it is entirely absent. It is important to remember that—

1. Cleavage is the same in all varieties of the same mineral.

2. It occurs parallel to the faces of the fundamental forms.

MASSIVE STRUCTURE.

Massive minerals occur in a variety of forms. They may consist of grains, of thin plates or leaves, or of minute columns. The first is called Granular, the second Lamellar, the third Columnar.

1. Granular structure is *coarsely granular* when the grains are coarse. Example, Limestones. It is *finely granular* when the grains are fine. Ex., Quartz. When no grains can be seen it is called impalpable. Ex., Chalcedony.

2. Lamellar structure. When the leaves are thin it is called *Foliaceous* or *micaceous*. Ex., Mica. When the plates are thick it is called *Tabular*. Ex., Barite.

3. Columnar structure.

Fibrous: when the columns are minute and are arranged like the grain of wood. Ex., Asbestus.

Reticulated: when the fibres cross like a net.

Stellated: when the fibres radiate from a centre after the manner of a star. Ex., Stilbite.

The forms of structure sometimes imitate familiar objects. They are then called —

1. Globular: when the shape is nearly spherical.

2. Reniform: when the form is more or less kidney-shaped.

3. Botryoidal: when a surface consists of rounded prominences like a bunch of grapes.

4. Mammillary: when the prominences are somewhat larger than the botryoidal.

5. Filiform: similar to a thread.

6. Auricular: like a needle.

7. Stalactitic: when the form is that of a cylinder or cone.

8. Drusy: when the surface is covered with minute crystals.

9. Amorphous: when there is no regular structure or form.

A pseudomorphous crystal has a different form from that in which the substance usually crystallizes.

CHAPTER III.

PHYSICAL CHARACTERS OF MINERALS.

HARDNESS.

The comparative hardness of minerals is ascertained by scratching with some hard substance, as a knife or a file, and comparing the result with other minerals taken as standards.

Ten minerals have been selected, and this is called the Scale of Hardness.

1. Talc. Laminated light green variety. Easily scratched by the nail.

2. Gypsum or Rock Salt. Not easily scratched by the nail. Does not scratch nickel coin.

3. Calcite. Transparent variety. Scratches and is scratched by a copper coin.

4. Fluor Spar. Crystalline variety. Does not scratch glass.

5. Apatite. Transparent variety. Scratches glass with difficulty. Easily scratched by a knife.

6. Orthoclase. White, cleavable variety. Scratches glass easily. Not easily scratched by a knife.

7. Quartz. Transparent variety. Not scratched by the knife. Scarcely affected by a file.

8. Topaz. Transparent variety. Harder than flint.

9. Sapphire. Transparent variety. Harder than flint.

10. Diamond. Harder than flint.

SPECIFIC GRAVITY.

The Specific Gravity of a substance is its weight compared with an equal bulk of some other substance taken as a standard. The standard for solids is pure water at 60° F.

Rule 1. For solids heavier than water.

Weigh the mineral in air. Next weigh in water and subtract this weight from the weight in air. This gives the loss of weight in water, or in other words the weight of an equal bulk of water. Divide the weight in air by the weight of the equal bulk of water. The result is the specific gravity.

Rule 2. For solids lighter than water.

Attach the substance to be weighed to another heavy enough to sink both in water. Weigh them both in air and in water. Find the loss. This gives the weight of a bulk of water equal to both minerals. Subtract the loss in water of the first mineral alone from the loss of both. This gives the weight of a bulk of water equal to the light substance. Divide the weight of the light mineral in air by the last result, for the specific gravity.

For accurate results allowance must be made for temperature and barometric pressure. These corrections may be in general omitted.

FRACTURE.

By fracture is meant the appearance of the surface when broken.

1. Even: when the surface is nearly flat. Ex., Calc Spar.

2. Uneven: when the surface is rough with frequent elevations and depressions. Ex., Talc.

3. Hackly: when the elevations are sharp or jagged. Ex., Broken Iron.

4. Conchoidal: when the surface is curved like a shell. Ex., Flint.

TASTE.

Soluble minerals only have taste.

1. Saline: the taste of common salt.
2. Alkaline: the taste of soda.
3. Astringent: the taste of vitriol.
4. Sweetish-astringent: taste of alum.
5. Other common terms are used.

STATE OF AGGREGATION.

Minerals are said to be —

1. Brittle: when the parts of the mineral crumble to powder on attempting to cut it. Ex., Halite.

2. Sectile: when thin slices can be cut with a knife. Powders under a hammer. Ex., Argentite.

3. Malleable: when slices can be cut that flatten under a hammer. Ex., Gold.

4. Flexible: when the mineral will bend and remain bent. Ex., Talc.

5. Elastic: when the mineral will bend and spring back. Ex., Mica.

Fluids may be gaseous or liquid.

CHARACTERS DEPENDING ON LIGHT.

There are five characters depending on light. They are —

Lustre; Color; Diaphaneity; Refraction; Phosphorescence.

Lustre.

Lustre depends upon the power of minerals to reflect light.

Lustres may differ in kind and in intensity.

Kinds of lustre: —

1. Metallic: the lustre of metals. When imperfect it is sub-metallic.
2. Vitreous: lustre of broken glass. Ex., Quartz.
3. Resinous: lustre of yellow resins. Ex., Amber.
4. Pearly: like pearl. Ex., Talc.
5. Silky: like silk. Ex., Fibrous Gypsum.
6. Adamantine: the lustre of the diamond.

Degrees of intensity: —

1. Splendent: very brilliant and gives well-defined-images. Ex., Tin ore.

2. Shining: when an image is produced, but not well-defined. Ex., Calc Spar.

3. Glistening: when there is reflection, but no image. Ex., Talc.

4. Glimmering: when there is but an imperfect reflection. Ex., Flint.

When a mineral has no lustre it is said to be dull. Chalk is an example.

Color.

Color depends upon the power of a mineral to arrest or modify and reflect rays of light.

The colors are either metallic or non-metallic.

The metallic colors are named from familiar metals, as lead-gray, copper-red, &c.

The non-metallic colors are the various ordinary colors, as snow-white, sky-blue, apple-green, bluish-green, &c.

Play of colors is a display of prismatic colors on turning the mineral. Ex., Diamond.

Opalescence is a milky reflection from the interior of a mineral, as in some opals.

Iridescence is when prismatic colors occur within a crystal or specimen, as in some varieties of mineral coal.

Tarnish is when the surface has changed from exposure.

Dichroism is when a mineral has different colors in two directions, as in Iolite. Sometimes this occurs in Mica.

Diaphaneity.

Diaphaneity is the power a substance possesses of transmitting light.

Four degrees of diaphaneity are usually recognized.

1. Transparent: when the outlines of objects viewed through the substance may be seen distinctly. Ex., Glass.

2. Subtransparent: when objects can be seen but indistinctly. Ex., Selenite.

3. Translucent: when light passes through but objects cannot be seen. Ex., Loaf Sugar.

4. Sub-translucent: when only the edges transmit light dimly. Ex., Cuprite.

Opaque is when no light is transmitted. Ex., Graphite.

Refraction.

Refraction is the bending of light rays in their passage through bodies of different density. From air to water is an example. An object seen obliquely in the water is seen beyond its real position.

Different substances possess this power in different degrees. The following represent a few: —

Air, 1	Calc Spar, 1.65
Water, 1.34	Diamond, 2.44
Quartz, 1.55	Chromate of Lead, 2.97

Double Refraction. — Many minerals possess the power of refracting light in two directions. This power is called Double Refraction. This may be observed by looking through a piece of Iceland Spar. A dot or letter will appear double. Minerals

of the Isometric System, or those with equal axes, do not in general possess this power.

Polarized Light. — One of the refracted rays exhibits the peculiar property known as Polarized Light. This ray on being passed through another doubly-refracting crystal or analyzing plate, becomes alternately visible and invisible, and beautiful rings of prismatic colors are produced. A very useful instrument for measuring the amount of sugar in a liquid has been made by employing this principle of Polarized Light.

Phosphorescence.

Phosphorescence is the power some substances possess of emitting light.

This may be seen when Fluor Spar is powdered and heated on a shovel. Several minerals exhibit this power by friction or heating, as Quartz or Sugar, Zinc, Blende, &c.

Many minerals possess also the property of Electricity and Magnetism.

CHAPTER IV.

CHEMICAL CHARACTERS OF MINERALS.

BLOWPIPE.

The Blowpipe is an instrument employed in heating, volatilizing, oxidizing or reducing minerals on a small scale.

By blowing a jet of air into the interior of a

flame, the combustion is rendered more rapid and the intensity of heat increased. The flame has a small blue central cone, and a large yellow exterior cone.

By placing a metal, as lead, at the point of the outer flame it is oxidized, hence this is called the Oxidizing Flame. If, on the other hand, we place an oxide, as an oxide of lead, at the point of the blue central flame it loses oxygen. That is it is reduced. This is therefore called the Reducing Flame.

The blowpipe in its simplest form is a bent tube eight or ten inches long, terminating at one end in a small orifice.

BLOWING WITH THE BLOWPIPE.

Some practice is required to keep a continuous current of air through the blowpipe. This is accomplished by forcing air from the mouth by a compression of the cheeks, while breath is taken through the nose.

The mineral for examination is usually supported either on charcoal or by a loop of platinum wire. A small glass tube is employed in testing the presence of water.

FLUXES.

Many substances require in fusion the aid of fluxes.

The most common fluxes are: —

Sodium Carbonate.

Sodium Biborate or Borax.

Microcosmic Salt.

These fluxes, when fused to a clear globule and united with a grain of the powdered mineral, give certain reactions and changes of color by which the composition of many minerals may be determined.

ACIDS.

The acids usually employed in testing minerals are Chlorhydric Acid, Sulphuric Acid, and Nitric Acid. These acids, when applied to certain minerals, especially the carbonates, produce a chemical decomposition. Thus a limestone when touched by either of these acids gives off bubbles of gas. This is called effervescence. The mineral may be powdered and put in dilute acid. Sometimes heating is necessary to produce chemical action.

Many silicates when allowed to remain in strong acid become changed to a jelly-like mass.

CHAPTER V.

CLASSIFICATION OF MINERALS.

A mineral has been defined as including all inorganic substances in nature.

The entire inorganic world consists of 68[1] simple substances or elements. Of these about 14 may be regarded as common, the others occur more rarely. These substances in general occur in combination. Thus water is composed of two parts of hydrogen and one of oxygen. Galenite is com-

[1] See table of symbols and atomic weights, page 16.

posed of Lead and Sulphur. It is called a Lead Sulphide or Ore of Lead. Magnesite is composed of Magnesium, Carbon and Oxygen. It is called a Carbonate of Magnesia, or better, Magnesium Carbonate.

Thus minerals occur—

1. As Elements, or bodies composed of a single substance.

2. As Compounds, composed of two elements.

3. As Compounds, composed of three elements.

The Metallic Elements usually end in "um" or "ium." Thus Gold (Aurum), Lead (Plumbum), Silver (Argentum), Sodium, etc.

The compounds of two elements are called Binary Compounds and usually end in "ide."

The Compounds of three elements are called Ternary Compounds and generally end in "ate."

It has been thought best to adopt this classification as far as practical; although in a work of this kind it would be useless to attempt any great degree of scientific exactness.

GENERAL ORDER OF CLASSIFICATION.

I. GASES.

II. ELEMENTS.

III. BINARY COMPOUNDS.

1. Sulphides.
2. Arsenides.
3. Fluorides.
4. Oxides.

IV. TERNARY COMPOUNDS.

1. Sulphates.

2. Phosphates.
3. Carbonates.
4. Silicates.
5. Nitrates.
6. Arsenates.
7. Molybdates.
8. Borates.

SYMBOLS AND ATOMIC WEIGHTS.

	Symbol.	At. Wt.		Symbol.	At. Wt.
Aluminium	Al	27.4	Mercury (Hydrargyrum)	Hg	200
Antimony (Stibium)	Sb	122	Nickel	Ni	59
Arsenic	As	75	Nitrogen	N	14
Barium	Ba	137	Osmium	Os	199
Bismuth	Bi	210	Oxygen	O	16
Boron	B	11	Palladium	Pd	106.6
Bromine	Br	80	Phosphorus	P	31
Cadmium	Cd	112	Platinum	Pt	197
Cæsium	Cs	133	Potassium (Kalium)	K	39
Calcium	Ca	40	Rhodium	Rh	104.3
Carbon	C	12	Ruthenium	Ru	104.2
Cerium	Ce	92	Rubidium	Rb	85
Chlorine	Cl	35.5	Selenium	Se	79
Chromium	Cr	52.2	Silicium	Si	28
Cobalt	Co	58.8	Silver(Argentum)	Ag	108
Columbium	Cb	94	Sodium(Natrium)	Na	23
Copper (Cuprum)	Cu	63.4	Strontium	Sr	87.6
Didymium	D	95	Sulphur	S	32
Erbium	E	112.6	Tantalum	Ta	182
Fluorine	F	19	Tellurium	Te	128
Glucinum	G	9.4	Terbium		?
Gold (Aurum)	Au	197	Thorinum	Th	115.7
Hydrogen	H	1	Thallium	Tl	204
Indium	In	74	Tin (Stannum)	Sn	118
Iodine	I	127	Titanium	Ti	50
Iridium	Ir	198	Tungsten (Wolfram)	W	184
Iron (Ferrum)	Fe	56	Uranium	U	120
Lanthanum	La	93.6	Vanadium	V	51.2
Lead (Plumbum)	Pb	207	Yttrium	Y	61.7
Lithium	Li	7	Zinc	Zn	65
Magnesium	Mg	24	Zirconium	Zr	89.6
Manganese	Mn	55			
Molybdenum	Mo	96			

CHAPTER VI.

GASES.

I. ATMOSPHERIC AIR.

It is the air we breathe. It consists of 21% of Oxygen and 79% of Nitrogen. Ratio 1—4. It has neither odor, color nor taste. It supports life and combustion by means of the oxygen it contains. It is 815 times lighter than water.

II. NITROGEN GAS.

It is colorless, odorless and tasteless; does not support life.

It escapes from many springs. Some springs are said to yield 300 cubic inches a minute.

III. CARBURETED HYDROGEN.

It consists of Carbon 75%, Hydrogen 25%. Burns with a yellow flame. It is nearly the same as the illuminating gas of our cities. It issues in abundance from some coal beds, and sometimes from pools of water. The village of Fredonia, N. Y., is said to be lighted by this gas.

IV. PHOSPHURETED HYDROGEN.

It consists of Phosphorus 91%, and Hydrogen 9%. Takes fire spontaneously. Jack-o'-lanterns are supposed to be this gas.

V. SULPHURETED HYDROGEN.

It consists of Sulphur 94%, Hydrogen 6%. It burns with a pale-blue flame, and has the odor of

putrescent eggs. It is found about sulphur springs and volcanoes.

VI. CHLORHYDRIC ACID.

It consists of Chlorine 97%, Hydrogen 3% nearly. It is pungent and acrid. It is an important agent in testing minerals.

VII. CARBONIC ACID.

It extinguishes combustion and destroys life. Its taste is pungent. Its composition is 27.6% Carbon, and Oxygen 72.4%.

It occurs in mineral waters and about volcanoes. It gives the acid taste to the well-known soda water, which is made by condensing carbon dioxide in water.

Calcite is a chemical union of calcium and carbonic acid.

VIII. SULPHURIC ACID.

It is found in river waters, sulphur springs, and about volcanoes. It consists of Sulphur 40%, Oxygen 60%. It is estimated that one river in South America carries to the sea more than 38,000 kilogrammes of this acid daily.

The Sulphates are a union of the different metals with sulphuric acid. Thus gypsum is a union of calcium with sulphuric acid.

CHAPTER VII.

ELEMENTS.

GOLD....Aurum.

Element.

Isometric System.

H. 2.5-3. Sp. Gr. 15-19.

1. *Occurrence.* It crystallizes in cubes or octahedra. It is usually found in threads or thin laminæ.

2. *Physical Characters.*

   a. Lustre, metallic.

   b. Color and streak are different shades of yellow.

   c. Very ductile and malleable.

3. *Chemical characters.* Fuses easily. No reaction with fluxes. Soluble in aqua regia.

4. *Diagnostic characters.* Distinguished from iron and copper pyrites by its high specific gravity and its softness. Gold flattens under a hammer. Pyrites crumble to a powder.

5. *Observations.* Native gold is usually alloyed with silver, copper and lead, in various proportions. The gold of Nova Scotia is nearly pure. That of Canada contains 92% of pure gold. That of Australia 96%, that of California 98%.

The principal gold mines of the world are in Hungary, in Spain, on the eastern slopes of the Ural Mountains, in Australia, and in the western part of America (California and Chili).

It is generally found in a free state.

When in quartz rock it is said to be in situ.

The rocks containing gold have often been decomposed or broken up. These products have been washed out and deposited in the beds of streams, thus forming the alluvial gold-bearing sands, from which the gold is separated by washing, by the so-called hydraulic process, or by the use of mercury.

Machinery and capital are now extensively employed, and gold is mostly obtained by the crushing of gold-bearing quartz rock.

SILVER....Argentum.

Element.

Isometric System.

H. 2.5–3. Sp. Gr. 10–11.

1. *Occ.* This metal crystallizes in cubes and octahedra. It is also found in filiform and arborescent shapes, and sometimes in laminæ.

It usually occurs alloyed with copper, sometimes with gold and bismuth.

2. *Phys.* *a.* Lustre, metallic.
b. Color and streak, silver white.
c. Ductile, sectile, malleable.

3. *Chem.* Fuses easily. Dissolves in nitric acid.

4. *Diag.* Distinguished by its malleability. Differs from bismuth and other white native metals by affording no fumes before the blowpipe.

5. *Obs.* Much of the galena of the West contains a small per centum of silver.

Localities are Norway, Saxony, Asiatic Russia,

Peru, Mexico, and west of the Rocky Mountains; also at Lake Superior associated with copper. A mass found in Southern Peru weighed 8 cwt.; one from Frieberg weighed 14 cwt.

Silver is used for making articles of ornament, for plating other metals, for coining, and for various purposes in the arts. For coining in this country it is alloyed with 10% of copper.

COPPER....Cuprum.

Element.

Isometric System.

H. 2.5–3. Sp. Gr. 8–9.

1. *Occ.* Its crystals are cubes and octahedra, like those of gold and silver.

Often occurs in masses and thin sheets.

2. *Phys.* *a.* Lustre, metallic.
   b. Color, copper-red.
   c. Streak, metallic and shiny.
   d. Fracture, hackly.
   e. Ductile and malleable.

3. *Chem.* Fuses readily. Soluble in acids.

4. *Diag.* Readily distinguished by its metallic lustre and red color.

5. *Obs.* It is found in Siberia, Cornwall, Brazil and Chili.

The most remarkable locality is the Lake Superior region. Masses weighing many tons have been found here; the largest mass weighed 420 tons and contained 90% of copper.

This metal was known in the earliest times, and was chiefly used alloyed with tin, forming bronze.

Copper alloyed with 30 to 50 % of zinc forms brass; when alloyed with 10 to 30 % of tin forms bronze and bell-metal.

Is also used for sheathing ships, for coining, and for casting statues.

Antimony....Stibium.

Element.

Hexagonal System.

H. 3.35. Sp. Gr. 6.6 – 6.7.

1. *Occ.* Metallic Antimony is often found native. It usually enters into combination with sulphur and lead. It also combines with oxygen, lime, and silver. Occurs in lamellar masses.

2. *Phys.* *a.* Lustre, bright and metallic.
b. Color and streak, tin-white.
c. Very brittle.

3. *Chem.* Fuses easily, and passes off in white fumes. It forms a white ring at some distance from the assay.

4. *Diag.* Distinguished from arsenic in being less volatile.

5. *Obs.* It is found in veins of silver in Bohemia, Sweden, and Mexico. It has also been found at Warren, N. J.

The varieties having large lamellæ are nearly pure. The others contain more or less arsenic. The small lamellæ indicate a large percentage of arsenic. The varieties generally contain one or two per cent. of impurity.

Antimony with lead is used in type metal. It forms an important part of the britannia metal.

The tartrate of antimony and potassa is tartar emetic.

SULPHUR.

Element.

Orthorhombic System.

H. 1.5 – 2.5. Sp. Gr. 2.

1. *Occ.* Is found massive and crystallized. Its regular crystal is the right rhombic prism. It generally crystallizes, however, in rhombic octahedra. From fusion at high temperature it crystallizes in oblique rhombic prisms belonging to the monoclinic system. As it crystallizes in two systems it is called dimorphous.

2. *Phys.* *a.* Lustre, resinous.
   b. Color and streak, sulphur-yellow, orange-yellow, grayish and greenish.
   c. Fracture, subconchoidal.
   d. Very brittle.
   e. Transparent, translucent, opaque.

3. *Chem.* On charcoal burns with a faint blue flame, giving off sulphurous odor.

   Insoluble in acids.

4. *Diag.* Is readily distinguished from other minerals by its color, by its odor when heated, and by its blue flame when burned.

5. *Obs.* Is found in the region of active or extinct volcanoes. 80,000 tons are annually exported from Italy and Sicily, its chief localities. It is roughly purified before exportation.

Sulphur of commerce is also obtained from copper and iron pyrites.

Is largely used in the arts for preparing sulphuric acid and in bleaching.

Is a constituent of gunpowder, of which it forms 9 to 20 %.

BISMUTH.

Element.

Hexagonal System.

H. 2–2.5. Sp. Gr. 9.7.

1. *Occ.* It crystallizes as a rhombohedron. Is generally found massive, with distinct cleavage, sometimes granular.

2. *Phys.* *a.* Lustre, metallic.
b. Color and streak, silver white.
c. Sectile.
d. Subject to tarnish.
e. Brittle when cold, slightly malleable when heated.

3. *Chem.* It melts in the flame of a candle. On charcoal it evaporates, leaving a yellow coating. It is not attacked by chlorhydric acid, but dissolves in nitric acid.

4. *Diag.* It is distinguished from cobalite and sinmarite by its lamellar fracture and blowpipe reaction.

5. *Obs.* In the U. S. it has been found at Munroe, Ct., and in South Carolina.

It is used in making type metal, plumber's solder, mosaic gold and "fusible metal."

METEORITE.

Native Iron.

Isometric System.

H. 4.5. Sp. Gr. 7.3–7.8.

1. *Occ.* Native Iron is of meteoric origin. It is rarely found of terrestrial origin. The iron of meteorites is nearly always alloyed with 8–10% of nickel and cobalt. Usually massive, with traces of crystallization.

2. *Phys.* *a.* Lustre, metallic.
b. Color, iron-gray. Streak, shining.
c. Ductile and magnetic. Malleable.

3. *Chem.* Fusible. Soluble in acids.

4. *Diag.* Most meteorites are of a stony character, containing the iron scattered through them in bunches. The surface is covered with a coating that seems to have been melted and blackened. The stone is grayish and porous or spongy. On a polished surface of the metal triangular figures are developed by nitric acid.

5. *Obs.* The Gibbs meteorite of Yale College weighs about 1,600 lbs. One of the Smithsonian Institute weighs 1,400 lbs. A celebrated meteorite in South America is estimated at 32,000 lbs.

There are many interesting theories in regard to their origin and mode of appearance.

DIAMOND.

Carbon (pure).

Isometric System.

H. 10. Sp. Gr. 3.5.

1. *Occ.* The diamond is found in nature in

three different states, sometimes crystallized, sometimes as a concretion, and amorphous. Crystals often have rounded faces.

Its usual form is the octahedron, the cube is sometimes found, as well as more complex forms.

It has never been found in place, but in alluvial formations.

2. *Phys.* *a.* Lustre, adamantine.
b. Color, white or colorless, and various tints.
c. Transparent, translucent.
d. Strongly refracts and disperses light, hence its brilliancy.

3. *Chem.* It may be burned in oxyhydrogen blowpipe flame, producing carbonic acid gas. Insoluble in acid.

4. *Diag.* It is the hardest form of matter known. Is not readily distinguished from some of its numerous imitations except by the chemist or the skilful lapidist.

6. *Obs.* Diamonds formerly came chiefly from the mines of India, now no longer worked. At present they come chiefly from Brazil, the Urals, where they were discovered by Humboldt in 1829, and from the recently discovered locality in South Africa. Specimens have been found in North Carolina, Virginia, California, and, according to report, in Idaho and Alaska. The Brazilian mines were opened in 1727; since that time it is estimated that they have produced two tons of diamonds.

Rough diamonds lose nearly nine-twentieths of their weight in cutting. The ancients knew no

way of cutting the diamond, but wore only the natural crystals. It is now cut by taking advantage of its cleavage to remove its outer coatings and grinding with its own dust to form and polish the faces. The process is a slow one. It was discovered in 1456, by Louis Berquen of Bruges. Diamonds not fit for cutting are used for powder in grinding, for drills and lathes in working hard rocks, as granite and porphyry, and also for cutting glass. The fine splinters are used as drills for perforating gems, artificial teeth, &c.

There are three forms of cutting diamonds, the rose, the brilliant and the table. The brilliant gives the finest effect, the rose is used for thinner stones, and the table, formerly the usual form, is now little used.

The value of diamonds is very variable. An approximate rule is, multiply the square of the weight in carats by twelve. The result is the value in pounds sterling. But the value is often arbitrarily fixed. Limpid diamonds, containing no defects, and crystallized, are said to be of the first water; those slightly colored and with few defects, are of the second or third water. Stones of deep colors, as blue, red, green and black, are valued for their rarity.

The diamond has probably been formed like coal, by the decomposition of substances containing carbon, whether animal or vegetable. It is changed into graphite by continued electric action, which seems a proof that both are allotropic forms of carbon formed at different temperatures.

Many attempts have been made to produce diamonds artificially, but only minute crystals, if any, have been obtained.

A diamond of five or six carats is a very large stone; those of fifteen to twenty are very rare, and only a very few weigh more than 100 carats.

WEIGHT OF HISTORIC DIAMONDS.

Rajah, 367 carats.

Great Mogul, 279 carats; uncut, 900.

Orloff, 194, formed the eye of a Braminican idol, and was purchased by Catharine II. of Russia from a French grenadier who had stolen it.

Koh-i-noor, 186; uncut, 793; recently recut, present weight 106.

Regent, 136; uncut, 410; the most splendid of Indian diamonds.

Star of the South, 125; uncut, 251; from Brazil in 1854.

MINERAL COAL.

Impure Carbon.

Massive.

H. 1 – 2.5. Sp. Gr. 1.2 – 1.7.

1. *Occ.* Mineral coal occurs in extensive beds or layers, alternating usually with clay shales or beds of limestone.

2. *Phys.* *a.* Lustre, vitreous to resinous. Sometimes iridescent.
b. Color, black or brown.
c. Opaque. Brittle.

3. *Chem.* The bituminous varieties burn with a bright flame and dense smoke. Anthracite burns with a pale blue flame.

4. *Diag.* Easily distinguished by its low specific gravity, its softness and brittle texture.

5. *Varieties.*

I. Anthracite.

Black, semi-metallic in lustre, burns without odor or smoke. Is more compact than other varieties. It is used extensively for fuel.

II. Bituminous.

Contains a large proportion of bitumen, is softer and less lustrous than anthracite. Burns with a bright yellow flame and bituminous odor.

There are several varieties, which may be classed under five divisions.

(1) Brown Coal or Lignite, contains about 60% of carbon. It has a brown color and streak, and burns more readily than common black coal.

(2) Caking Coal in burning breaks into fragments, then runs together forming a mass. The Newcastle coal is a variety.

(3) Cherry or Soft Coal is an abundant variety; velvet-black in color, has a splendid resinous lustre, does not cake, and burns readily with a cheerful flame, leaving few cinders.

(4) Cannel or Parrot Coal is so called from its burning with a clear flame, like a candle, and its chattering or crackling sound in burning. Its lustre varies from earthy to a brilliant or shining waxy lustre. It is always compact, and takes a good polish. Jet is a variety.

(5) Naphtha, or petroleum, is a mineral oil. It occurs in the inclined strata of both the older and more recent formations. The naphtha of Canada

is of Silurian origin, that of Pennsylvania is Devonian, while the naphtha of California comes from Tertiary rocks. It results from the decomposition of organic matter, both vegetable and animal.

6. *Obs.* Mineral Coal is of vegetable origin, and is the product of the decomposition of plants of the Carboniferous Age. It is widely distributed.

The coal areas of the U. S. are:—

1. Rhode Island..............	1,000	square	miles.
2. Appalachian................	60,000	"	"
3. Michigan..................	5,000	"	"
4. Illinois and Missouri.......	60,000	"	"

Total for the U. S. is about 130,000 square miles.

The areas of some of the principal foreign districts are:—

Great Britain and Ireland.....	12,000	square	miles.
Spain.......................	4,000	"	"
France......................	2,000	"	"
Belgium.....................	520	"	"

Nova Scotia and New Brunswick have 18,000 square miles.

The ratio is nearly 150,000 in North America against 20,000 in the localities of Europe. As a source of national prosperity, the value of these inexhaustible stores of force cannot be overestimated.

GRAPHITE....Plumbago.

Impure Carbon.

Hexagonal System.

H. 1-2. Sp. Gr. 2.09.

1. *Occ.* It is sometimes found in six-sided tabular prisms. It generally occurs massive.

Graphite is carbon in nearly a pure state, generally containing admixtures of clay, silica, and oxide of iron. It may be regarded as a product of the coal period, and is therefore of vegetable origin.

2. *Phys.* *a.* Lustre, metallic.
   b. Color, black to gray.
   c. Streak, black, shining.
   d. Very sectile.

3. *Chem.* Infusible. Not affected by acids.

4. *Diag.* It has a greasy feel, and soils the fingers. Distinguished from molybdenite by blowpipe characteristics. Molybdenite has a bluish color.

5. *Obs.* It is found in most of the New England States. Principal locality is in England.

Extensively used in the arts; for lead pencils, as a lubricator, and for polishing iron.

For the manufacture of lead pencils it is first powdered, then by great pressure is reduced to solid sheets, from which the required forms are obtained.

CHAPTER VIII.

BINARY COMPOUNDS.

SULPHIDES.

GALENITE ... { Lead, 86%. Sulphur, 14%.

Lead Sulphide.

Isometric System.

H. 2.5. Sp. Gr. 7.5.

1. *Occ.* Crystallizes like gold, silver and copper

in cubes and octahedra. Is often found in crystalline masses, usually disseminated in quartz, calcite or barite.

2. *Phys.* *a.* Lustre, shining metallic.
b. Color, grayish blue.
c. Streak, lead-gray.
d. Cleavage, perfect in three directions, cubic.
e. Fracture, lamellar.

3. *Chem.* Fuses on charcoal, yielding sulphur fumes and a globule of metallic lead.

Soluble in acids.

4. *Diag.* Its cubical cleavage distinguishes it from stibnite and molybdenite.

5. *Obs.* This is by far the most important ore of lead. Is found abundantly in Missouri, Illinois, Wisconsin and Iowa.

There is probably no specimen of Galenite which does not contain some silver. The ore is often worked for the silver it contains.

Is used largely in the arts, both alone and alloyed with other metals.

ARGENTITE .. { Silver, 87. Sulphur, 13.

Silver Sulphide.

Isometric System.

H. 2-2.5. Sp. Gr. 7.2-7.4.

1. *Occ.* It is often found in cubes and octahedra grouped with other forms. Also occurs massive.

2. *Phys.* *a.* Lustre, metallic, opaque.
b. Color, iron-black, with little color on the faces.

c. Streak, black, shining.
d. Brittle, ductile.

3. *Chem.* Fuses easily without a blowpipe. Gives off a sulphurous odor. Reduces to a globule of silver. Soluble in nitric acid.

4. *Diag.* Resembles many ores of lead and copper. Distinguished by blowpipe characters. Its specific gravity is higher than the copper ores. It can be cut with a knife and retains the impression of a hammer.

5. *Obs.* This is a very valuable ore of silver. The American localities are in Nevada, Mexico and South America.

CINNABAR ... { Mercury, 86. Sulphur, 14. }

Mercury Sulphide.

Hexagonal System.

H. 2–2.5. Sp. Gr. 9.

1. *Occ.* Crystallizes in rhombohedrons. Usually occurs in lamellar, granular and compact masses.

2. *Phys.* *a.* Lustre, adamantine or dull.
b. Color, cochineal-red with a violet tinge. Sometimes black.
c. Streak, always red.

3. *Chem.* Volatilizes without residue. Insoluble in acids.

4. *Diag.* Easily distinguished by its color and high specific gravity.

5. *Obs.* Cinnabar is the ore of mercury, from

which the mercury of commerce is obtained. Used as a pigment called vermilion.

Principal locality is in California.

CHALCOCITE.. { Copper, 80.
Sulphur, 20.

Copper Sulphide.

Orthorhombic System.

H. 2.8. Sp. Gr. 5.5-5.8.

1. *Occ.* It crystallizes as a right rhombic prism. Also occurs in lamellar masses.

2. *Phys.* *a.* Lustre, metallic.
b. Color and streak, dark blue to black.
c. Ductile,.may be cut with a knife into curved shavings.

3. *Chem.* Melts readily in a flame and gives off sulphurous fumes. Dissolves in hot nitric acid.

4. *Diag.* Resembles argentite, but is less sectile. May also be distinguished by its lustre and blowpipe reactions.

5. *Obs.* This ore is often alloyed with silver. Beautiful specimens are found at Bristol, Conn. Occurs also in New York, New Jersey and elsewhere. This mineral is strictly a cuprous sulphide (Cu_2S). Cupric Sulphide (CuS) is found native as the mineral Covellite.

BORNITE .. { Copper, 70.
Iron, 8.
Sulphur, 22.

Copper and Iron Sulphide.

Isometric System.

H. 3. Sp. Gr. 5.

1. *Occ.* Crystallizes in cubes and octahedra. Is also massive. Occurs with other ores of copper.

2. *Phys.* *a.* Lustre, metallic.
b. Color, reddish brown.
c. Streak, blackish, bronze-yellow.
d. Brittle. Shows a brilliant play of colors.

3. *Chem.* Fuses partially to a magnetic globule. Soluble in nitric acid.

4. *Diag.* It is distinguished from Chalcopyrite by its reddish color.

5. *Obs.* Fine crystals occur at Bristol, Ct. It is found massive in Massachusetts, Pennsylvania and elsewhere.

Is known to miners as "horseflesh ore."

CHALCOPYRITE ... { Copper, 34, Iron, 31. Sulphur, 35.

Copper and Iron Sulphide.

Tetragonal System.

H. 3.5–4. Sp. Gr. 4.2.

1. *Occ.* The prism is very near the cube. Crystals are sometimes octahedra, but more usually sphenoids resembling tetrahedra. Is also found massive and in imitative shapes.

2. *Phys.* *a.* Lustre, metallic.
b. Color, brass-yellow, deeper than that of pyrite.
c. Streak, dull, unmetallic.

d. Fracture, uneven.

e. Is liable to tarnish and is often iridescent.

3. *Chem.* Fuses to a magnetic globule with sulphur fumes. Soluble in nitric acid.

4. *Diag.* Resembles native gold and iron pyrites. Is distinguished from gold by its brittleness, from pyrite by its deeper color, and by its crumbling instead of striking fire with steel.

5. *Obs.* Is a valuable ore of copper. Occurs in veins in granitic rocks, associated with galenite, blende, and copper carbonates.

Its chief foreign localities are Sweden and the Hartz. It is found sparingly in Massachusetts at the Southampton lead mines, in Maine at the Lubec lead mines. Also abundantly in Virginia and Wisconsin. In Michigan, where native copper abounds, this is a rare ore.

Is worked for its copper, and is also used in the manufacture of blue vitriol (sulphate of copper).

Is known as copper pyrites.

PYRITE ... { Iron, 47.
Sulphur, 53.

Iron Sulphide.

Isometric System.

H. 6-6.5. Sp. Gr. 4.8-5.2.

1. *Occ.* In cubes or octahedrons. It is generally imbedded in limestone or clay rocks. Sometimes found massive.

2. *Phys.* *a.* Lustre, metallic.

b. Color, brass-yellow.

c. Streak, brownish black.
d. Brittle, opaque.
e. Cleavage, distinct, parallel.

Chem. Fuses easily; becomes magnetic by heating. Dissolves in nitric acid.

4. *Diag.* Distinguished from Marcasite by its color, which is much deeper yellow; from Chalcopyrite by its greater hardness and paler color; from Gold by not being sectile or malleable; from the ores of Silver by its bronze yellow color. The silver ores are steel-gray or nearly black.

5. *Obs.* Iron pyrites is found almost everywhere, and is a very important ore. The copperas and sulphuric acid of commerce are made from it.

MARCASITE .. { Iron, 47. Sulphur, 53.

Iron Sulphide.

Orthorhombic System.

H. 6. Sp. Gr. 4.7 - 4.8.

1. *Occ.* Crystals, tabular or columnar, usually clustered or in groups, called radiated pyrites, spear pyrites, hepatic pyrites, &c., according to its form.

2. *Phys.* a. Lustre, metallic, or with a greenish tinge.
b. Color, lighter yellow than pyrite.
c. Streak, grayish or brownish black.
d. Cleavage, indistinct. Brittle. Tarnishes. Opaque.

3. *Chem.* Blowpipe reactions like pyrite.

4. *Diag.* Paler than pyrites and more likely to

tarnish. Forms of crystals are more complex than those of pyrites.

5. *Obs.* Has the same composition as pyrites, of which it is a dimorphic form. It is used for the same purposes as pyrite. Common in the U. S. Found massive at Cummington, Mass.

STIBNITE .. { Antimony, 72. Sulphur, 28.

Antimony Sulphide.

Orthorhombic System.

H. 2. Sp. Gr. 4.5–4.6.

1. *Occ.* Crystallizes in right rhombic prisms. Often found massive, granular, or in lamellar forms.

2. *Phys.* *a.* Lustre, shining.
b. Color and streak, lead-gray.
c. Brittle. Tarnishes.

3. *Chem.* Fuses very easily, giving off white sulphur fumes.

4. *Diag.* Distinguished by extreme fusibility.

5. *Obs.* Stibnite occurs in Maine, New Hampshire and Maryland. The antimony used in the arts comes chiefly from this ore.

PYRARGYRITE .. { Antimony, 60. Silver, 22. Sulphur, 18.

Antimony and Silver Sulphide.

Hexagonal System.

H. 2–2.5. Sp. Gr. 5.8.

1. *Occ.* Its primitive crystal is the rhombohedron. It often occurs in hexagonal prisms.

2. *Phys.* *a.* Lustre, metallic.
b. Color, black or dark red.
c. Streak, cochineal red.
d. Fracture, conchoidal.
e. Translucent.

3. *Chem.* On charcoal fuses and coats the coal; finally yields silver globule. Decomposed by nitric acid.

4. *Diag.* It resembles Proustite, another ore of silver, but is much darker in color and more opaque. Is distinguished from cinnabar, cuprite and hematite by its peculiar streak and by blowpipe reactions.

5. *Obs.* It is a valuable ore of silver and is found in considerable quantities in Nevada and Idaho.

Ruby silver ore is a general name given to pyrargyrite and proustite.

MOLYBDENITE.. { Molybdenum, 60. Sulphur, 40.

Molybdenum Sulphide.

Hexagonal System.

H. 1-1.5. Sp. Gr. 4.5.

1. *Occ.* Is usually found in tabular hexagonal prisms.

2. *Phys.* *a.* Lustre, metallic.
b. Color, pure lead-gray.
c. Streak, same as color with greenish tinge.
d. Laminæ flexible but not elastic.

3. *Chem.* On charcoal it burns, yielding sul-

phurous fumes and a yellow incrustation which is molybdic acid.

Is decomposed (not dissolved) by nitric acid.

4. *Diag.* Resembles graphite but is distinguished from it by its blue color.

Soils the fingers with a bluish-gray stain.

5. *Obs.* Occurs in granite, gneiss, mica, slate and allied rocks.

Is found at Blue Hill Bay, Brunswick, and Bowdoinham, Maine, in Massachusetts at Brimfield and Shutesbury.

SPHALERITE.. { Zinc, 67. Sulphur, 33.

Zinc Sulphide.

Isometric System.

H. 3.5-4. Sp. Gr. 4.

1. *Occ.* It crystallizes in obscure forms of the dodecahedron and octahedron. Generally found massive or fibrous. Cleavage is very perfect.

2. *Phys.* *a.* Lustre, adamantine to resinous, brilliant.
b. Color, honey-yellow, brown, red, or black.
c. Streak, white or reddish-brown.
d. Brittle, semi-transpar. or opaque.

3. *Chem.* Infusible. Gives off sulphur vapors. Soluble in chlorhydric acid.

4. *Diag.* The dark varieties resemble garnet and cassiterite, but its specific gravity distinguishes it.

It is characterized by its waxy lustre, perfect cleavage, and blowpipe reactions.

5. *Obs.* This is one of the most common ores of zinc. Found in many places in the United States. In Maine, at Lubec, Dexter; in Massachusetts, at Sterling and Southampton, also at Warren, N. H. It is almost always associated with galenite.

It is sometimes known as zinc blende, and is the ore from which white vitriol is obtained.

MILLERITE.. { Nickel, 65. Sulphur, 35.

Nickel Sulphide.

Hexagonal System.

H. 3-3.5. Sp. Gr. 4.6-5.5.

1. *Occ.* It is generally crystallized in small crystals.

2. *Phys.* *a.* Lustre, metallic.
b. Color, brass-yellow. Sometimes with iridescent tarnish.
c. Streak, bright.

3. *Chem.* Fusible to a magnetic globule with borax.

Dissolves in acids with the green color of nickel.

4. *Diag.* Distinguished by blowpipe reactions.

5. *Obs.* It is found of a radiated structure at the Gap mine, Pennsylvania. Nickel alloyed with iron renders it less liable to rust, but with steel it has the opposite effect.

Nickel is extensively used for plating.

BISMUTHINITE.. { Bismuth, 80. Sulphur, 20.

Bismuth Sulphide.

Orthorhombic System.

H. 2. Sp. Gr. 6.4 – 7.2.

1. *Occ.* Crystallizes as a right rhombic prism. Often found massive, with an easy cleavage.

2. *Phys.* *a.* Lustre, metallic. Opaque.
b. Color, lead-gray to tin-white, with a yellowish tarnish.
c. Streak, same as color.

3. *Chem.* Fuses readily; brown while hot; yellow on cooling. Soluble in nitric acid.

4. *Diag.* Distinguished from stibnite by its solubility in nitric acid.

5. *Obs.* It is found associated with native bismuth.

ARSENIDE.

ARSENOPYRITE.. { Iron, 34. Sulphur, 20. Arsenic, 46.

Iron Sulphide and Arsenide.

Orthorhombic System.

H. 5.5 – 6. Sp. Gr. 6 – 6.4.

1. *Occ.* Crystallizes in right rhombic prisms. It also often occurs massive. Is usually associated with ores of silver, lead, iron or copper.

2. *Phys.* *a.* Lustre, metallic, bright in fresh fracture, but becomes dull on exposure.
b. Color, silver-white.
c. Streak, dark grayish black.
d. Brittle.

3. *Chem.* On charcoal gives arsenical fumes, easily recognized by odor of garlic, and yields a globule of iron.

It is decomposed by nitric acid.

4. *Diag.* Is distinguished from Marcasite by its lighter color and its arsenic reaction.

5. *Obs.* This mineral is also known as mispickle and arsenical iron pyrites. It is found in Maine, at Blue Hill; in Massachusetts, at Worcester; in New Hampshire, at Haverhill and Jackson. Also occurs in numerous other localities.

FLUORIDES.

FLUORITE .. { Calcium, 51. Fluorine, 49.

Calcium Fluoride.

Isometric System.

H. 4. Sp. Gr. 3.25.

1. *Occ.* Usually crystallizes in cubes; is also found in octahedra and rhombic dodecahedra.

Often occurs massive in layers.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, blue, yellow, green in all shades.
c. Streak, white.
d. Fracture, lamellar and sometimes scaly.
e. Cleavage, perfect, octahedral.

3. *Chem.* Fuses to an enamel with decrepitation and tinges the flame red.

It is insoluble in chlorhydric or nitric acids, but

sulphuric acid dissolves it easily without effervescence, giving off hydro-fluoric acid, which attacks glass.

4. *Diag.* In its bright colors it resembles some gems, but its softness at once distinguishes it. Is distinguished from Apatite in being soluble only in sulphuric acid.

5. *Obs.* Massive fluorite takes a high polish and has been used from the earliest times for vases and similar ornaments.

From its great abundance in Derbyshire, England, it is sometimes called Derbyshire Spar.

Is found at Blue Hill Bay, Maine, and at West Moreland, New Hampshire.

Besides its use for ornaments it is used as a flux in reducing ores and for the manufacture of hydro-fluoric acid, which is used to etch glass.

CRYOLITE.. { Sodium, 32. Aluminum, 14. Fluorine, 54.

Sodium and Aluminum Fluoride.

Triclinic System.

H. 2.5. Sp. Gr. 3.

1. *Occ.* Generally occurs in rectangular snow-white masses.

2. *Phys.* *a.* Lustre, vitreous or pearly.
b. Color. It is generally white — sometimes reddish, or even black.
c. Fracture, lamellar or scaly.

3. *Chem.* Fuses easily in the flame without a blowpipe. Soluble in sulphuric acid.

4. *Diag.* Distinguished by its extreme fusibility.

5. *Obs.* This mineral has within a few years acquired considerable commercial importance. It is only found in Greenland. Philadelphia and Boston companies hold the right to mine there for ninety-nine years.

It is used in the arts for the manufacture of alum and soda.

CHLORIDES.

CERARGYRITE .. { Silver, 75.3.
Chlorine, 24.7.

Silver Chloride.

Isometric System.

H. 1 – 1.5. Sp. Gr. 5.4.

1. *Occ.* Crystallizes in cubes, octahedra or rhombic dodecahedra. Crystals are quite rare. Usually massive, often incrusting.

2. *Phys.* *a.* Lustre, resinous.
b. Color, white, gray or grayish green.
c. Streak, colorless and shining.
d. Translucent to nearly opaque.
e. Sectile, cuts like horn.

Chem. Fuses in flame of a candle. On charcoal gives silver globule.

Insoluble in nitric acid, but is dissolved by ammonia.

4. *Diag.* Is readily distinguished by its sectil-

ity and general resemblance to horn or wax. Hence called horn silver.

5. *Obs.* A very common and abundant ore. It is extensively worked in South America and Mexico, and has quite recently been found extensively in Arizona and Nevada.

The largest crystals known come from Poorman's Lode, Idaho.

HALITE ... { Sodium, 40. Chlorine, 60.

Sodium Chloride.

Isometric System.

H. 2.5. Sp. Gr. 2.1 – 2.3.

1. *Occ.* Crystallizes in cubes. It has a very easy cubical cleavage. Usually occurs granular or massive.

2. *Phys.* *a.* Lustre, vitreous.
b. Colorless, or sometimes gray, yellowish or reddish.
c. Brittle. Transpar. Taste, saline.

3. *Chem.* Decrepitates before the blowpipe; tinges flame yellow. Fuses in a closed tube. Soluble in water.

4. *Diag.* Distinguished most readily by its taste.

5. *Obs.* Rock salt is met in the sedimentary formations of almost every age. It is held in solution in sea water, which contains about 2.5% of salt. Solid hills are found in Spain and Poland. It is also obtained from inland lakes and springs by evaporation. Some of the wells of Syracuse, N. Y.,

yield 1 bushel of salt to 36 gallons of water. Sea water yields 1 bushel of salt to 350 gallons.

It is extensively used for domestic and chemical purposes.

With salt and sulphur England might supply the world.

SAL-AMMONIAC.. { Ammonium, 34. Chlorine, 66. }

Ammonium Chloride.

Isometric System.

H. 1.5 – 2. Sp. Gr. 1.5 2.

1. *Occ.* Crystallizes in regular octahedra. Usually found in white or yellowish incrustations.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, white to grayish.
c. Translucent to opaque.
d. Taste, saline and pungent.

3. *Chem.* It is dissipated before blowpipe. Soluble in three parts of water.

4. *Diag.* Distinguished by its peculiar taste and the form of its crystals; those of salt being in cubes.

5. *Obs.* It occurs in volcanic formations or along the borders of some lakes. The sal-ammoniac of commerce is obtained from decomposed animal matter, or from the soot of coal. It is a valuable article in medicine and in chemical analysis.

OXIDES.

LIMONITE.. { Iron Oxide, 86.6. Water, 14.4. }

Iron Oxide (hydrous).

Is never crystallized.

H. 5 – 5.5. Sp. Gr. 3.6 – 4.

1. *Occ.* Is always massive, found as concretions having a fibrous and radiated structure. Often forms extensive beds and is then worked as an ore.

2. *Phys.* *a.* Lustre, various. The fibrous varieties are silky; the botryoidal varieties, metallic. Often dull and earthy.
   b. Color, dark brown to ochre yellow.
   c. Streak, yellowish brown.

3. *Chem.* Gives off water and becomes red. Soluble in acids.

4. *Diag.* Is much softer than magnetite or hematite, and is further distinguished by yielding water when heated.

5. *Obs.* It is one of the most valuable ores of iron. Extensive beds are found in Connecticut, New York, Pennsylvania, Missouri and the West. Specimens are found at Richmond and Lennox, Mass. It is sometimes ground and used for polishing, and as yellow ochre is much used for paint.

Is known under various names, as bog ore, brown ochre, yellow ochre and brown hematite.

MAGNETITE.. { Iron, 72. Oxygen, 28.

Iron Oxide.

Isometric System.

H. 5.5 – 6.5. Sp. Gr. 5 – 5.2.

1. *Occ.* Crystals in octahedra or rhombic dodecahedra. It is often granular or in compact masses, and is then rendered impure by specular iron, pyrite or quartz.

2. *Phys.* *a.* Lustre, metallic; cleavage octahedral.
b. Color, iron-black Streak, black.
c. Brittle, opaque. Strongly magnetic.

3. *Chem.* Fuses with difficulty. Soluble in nitric and chlorhydric acids.

4. *Diag.* Distinguished especially by its black streak and magnetic properties.

5. *Obs.* It is one of the most important iron ores. "Masses of this ore in a state of magnetic polarity constitute what is called loadstone or native magnets." It is extensively used in the manufacture of iron.

Sometimes called magnetic iron ore.

HEMATITE . . . { Iron, 70. Oxygen, 30.

Iron Oxide (anhydrous).

Hexagonal System.

H. 5.5 - 6.5. Sp. Gr. 4.5 - 5.

1. *Occ.* Its regular crystal is the rhombohedron. It is also found in thin hexagonal scales and massive. Hematite often forms independent rocks and beds.

2. *Phys.* *a.* Lustre, metallic, splendent,—called Specular Iron. Lustre, earthy,—called Red Hematite.

b. Color, brown to black.
c. Streak, cherry-red or brownish red.
d. Fracture, conchoidal.

3. *Chem.* It is infusible. Dissolves slowly in hot chlorhydric acid.

4. *Diag.* Specular iron resembles some of the silver and copper ores; red hematite resembles cuprite and cinnabar. From all these this ore is distinguished by its red streak and also by blowpipe behavior.

5. *Obs.* This is one of the richest and most important ores of iron. In Missouri are two mountains which consist mainly of this ore. One, Pilot Knob, is 700 feet high; the other is 300 feet. Abounds in New York and Pennsylvania. The finest crystals come from Elba. Is worked as an ore, but the specular variety reduces with great difficulty.

It is also called, according to its form, red ochre, iron glance, micaceous iron, red chalk.

CHROMITE.. { Chromium Oxide, 68. Iron Oxide, 32.

Chromium and Iron Oxide.

Isometric System.

H. 5.5. Sp. Gr. 4.5.

1. *Occ.* Is found in octahedral crystals but is generally massive.

2. *Phys.* *a.* Lustre, semi-metallic.
b. Color, brownish black.
c. Streak, brown.
d. Fracture, uneven.

e. Opaque and slightly magnetic.

3. *Chem.* In oxidizing flame infusible; with borax gives a green glass.

In reducing flame is rounded on the edges. Is not attacked by acids.

4. *Diag.* Resembles magnetite, but is distinguished by its green glass with borax.

5. *Obs.* This mineral is found at Chester and Blandford, Mass. Also in New York, Vermont and elsewhere. It is used largely in the manufacture of pigments.

Chromium oxide gives its green color to the emerald, and chromic acid gives the ruby its rich, peculiar tint.

CUPRITE .. { Copper, 89.
Oxygen, 11.

Copper Oxide.

Isometric System.

H. 3.5–4. Sp. Gr. 5.85–6.15.

1. *Occ.* Generally crystallizes in octahedra. It occurs also massive.

2. *Phys.* *a.* Lustre, adamantine, semi-metallic or earthy.

b. Color, blood-red or deeper shades, even black.

c. Subtransparent to opaque. Brittle.

d. Streak, dark cochineal-red.

3. *Chem.* In the inner flame it is reduced to a globule of copper which is ductile and malleable. Tinges flame green. Soluble in chlorhydric acid.

4. *Diag.* It is less volatile than cinnabar, and

is distinguished from hematite and magnetite by its lustre and blowpipe characters.

5. *Obs.* This ore is frequently associated with limonite. It is a valuable ore of copper, but is not found in large quantities. Localities are Bristol, Conn., Somerville, N. J., and the Lake Superior region. This ore is a cuprous oxide (Cu_2O). The cupric oxide (CuO) is found native in the mineral melaconite.

CASSITERITE.. { Tin, 79. Oxygen, 21.

Tin Oxide.

Tetragonal System.

H. 6-7. Sp. Gr. 6.4-7.1.

1. *Occ.* Crystals in short prisms or pyramids imbedded or attached. Also massive, granular or fibrous. Cleavage imperfect.

2. *Phys.* *a.* Lustre, adamantine or resinous.
   b. Color, yellowish, reddish or brownish black.
   c. Streak, colorless or brownish.
   d. Translucent to opaque. Brittle.

3. *Chem.* Infusible. Slightly affected by acids.

4. *Diag.* It is distinguished from sphalerite and barite by its hardness (6-7); from vesuvianite, garnet and tourmaline, which it resembles in form, lustre and color, it is distinguished by its specific gravity and blowpipe reactions.

5. *Obs.* It is an important ore of tin.

The principal tin mines are in Great Britain. The mines of Cornwall are said to have been worked four hundred and fifty years before the Christian Era.

ZINCITE.. $\begin{cases} \text{Zinc, 80.} \\ \text{Oxygen, 20.} \end{cases}$

Zinc Oxide.

Hexagonal System.

H. 4–4.5. Sp. Gr. 5.5.

1. *Occ.* It is always found in crystalline masses, lamellar, cracked and striated.

Occurs with franklinite and in limestone.

2. *Phys.* *a.* Lustre, bright, almost adamantine.
b. Color, dark orange-red.
c. Streak, orange-yellow.
d. Cleavage, very distinct.

3. *Chem.* Infusible. Soluble in acids.

4. *Diag.* It is distinguished from red stilbite by its infusibility and associations.

5. *Obs.* Is used as an ore of zinc; is readily reduced and known to miners as red zinc ore.

It is found at Franklin, N. J.

RUTILE.. $\begin{cases} \text{Titanium, 61.} \\ \text{Oxygen, 39.} \end{cases}$

Titanium Oxide.

Tetragonal System.

H. 6–6.5. Sp. Gr. 4.2.

1. *Occ.* The simple crystals are in prisms often sharply bent.

The crystals are often acicular, penetrating quartz. It also occurs massive.

2. *Phys.* *a.* Lustre, metallic, adamantine.
b. Color, reddish yellow, brown.
c. Streak, light brown.

d. Fracture, conchoidal across the crystal, and lamellar parallel to it. Transparent. Opaque.

3. *Chem.* Infusible. Is not acted on by ordinary acids.

4. *Diag.* It differs from tourmaline, vesuvianite and pyroxene in its infusibility; from cassiterite by yielding no metal with soda.

5. *Obs.* The mineral is found in Pennsylvania and Iowa; also at Barre and Conway, Mass., and at Warren, Me.

Specimens of limpid quartz, penetrated by acicular crystals of rutile, form an elegant stone for jewelry. They are called by the French, Flèches d'Amour (love's arrows).

PYROLUSITE.. $\begin{cases}\text{Manganese, 64.}\\ \text{Oxygen, 36.}\end{cases}$

Manganese Di-Oxide.

Orthorhombic System.

H. 2–2.5. Sp. Gr. 4.8–5.

1. *Occ.* Crystallizes in small rectangular prisms, showing only the ends. Generally occurs massive or in reniform coatings.

2. *Phys.* *a.* Lustre, metallic.
b. Color, iron-gray.
c. Streak, black.
d. Opaque; very tender; stains paper.

3. *Chem.* Infusible. Forms a violet glass with borax.

4. *Diag.* Distinguished by blowpipe characters.

5. *Obs.* It is very brittle. Common in iron mines. It is used for making bleaching powders and for the manufacture of oxygen in the laboratory.

WAD.... $\left\{ \begin{array}{l} \text{Manganese Oxide} \\ \text{Iron Oxide} \end{array} \right\}$ Variable.

Impure Manganese Oxide (hydrated).

Massive.

H. 1. Sp. Gr. 3.7.

1. *Occ.* This mineral is found in two different states: 1st, in large amorphous masses; 2d, as a concretion.

2. *Phys.* *a.* Lustre, dull, earthy.
b. Color and streak, bluish or brownish black.
c. Is easily sectile.
d. It is very lightand soils the fingers.

3. *Chem.* Gives off water when heated and yields a violet glass with borax. Easily soluble.

4. *Diag.* Closely resembles other manganese oxides, but is lighter; soils chocolate-brown and gives off water.

5. *Obs.* Wad is abundant in New York, Blue Hill Bay, Me., Grafton, N. H., and other places. Is used for bleaching, for umber paint, and by the chemist in making chlorine gas. It is also called Asbolite, and when it contains cobalt, Earthy Cobalt. In some Limonite mines it has a silvery appearance and is called Silvery Manganese.

FRANKLINITE.. { Iron Oxide, 66.
Zinc Oxide, 17.
Manganese Oxide, 17.

Iron, Zinc and Manganese Oxide.

Isometric System.

H. 5.5 - 6.5. Sp. Gr. 5.

1. *Occ.* Its crystals are octahedra and dodecahedra. It usually occurs in coarsely granular masses.

2. *Phys.* *a.* Lustre, submetallic to vitreous.
b. Color, black.
c. Streak, dark reddish brown.
d. Brittle.
e. Slightly magnetic.

3. *Chem.* Infusible. Soluble in chlorhydric acid.

4. *Diag.* It resembles magnetite, but is distinguished by its streak and blowpipe behavior.

5. *Obs.* It is found in abundance at Sterling, N. J., and is used as an ore of iron and of zinc.

CORUNDUM .. { Aluminum, 53.
Oxygen, 47.

Aluminum Oxide.

Hexagonal System.

H. 9. Sp. Gr. 3.9 - 4.16.

1. *Occ.* Occurs crystallized in six-sided prisms. Also found massive or granular. Generally impure with iron oxide.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, red, blue, purple, yellow, gray or white.
c. Streak, colorless.

3. *Chem.* Infusible. Not acted on by acids.

4. *Diag.* Distinguished by its hardness. It scratches quartz crystals easily.

5. *Obs.* Except the diamond it is the hardest known substance. The finer varieties are gems of great value. According as they are red, blue, green, violet or yellow, they are known as the ruby, sapphire, emerald, amethyst or topaz. When massive it is called emery, and is used for polishing. Gems of an inferior quality have been found in various parts of the U. S.

The emery of commerce comes from Naxos, in the Mediterranean Sea. It is found in primitive and azoic rocks (granite and gneiss). Garnet has been mistaken for emery. The hardness of garnet is 7. That of corundum is 9.

QUARTZ ... { Silicon, 47. Oxygen, 53.

Silicium Oxide or Silica.

Hexagonal System.

H. 7. Sp. Gr. 2.5–2.7.

1. *Occ.* Quartz or Rock Crystal is nearly pure Silicic Acid. In combination with the metallic oxides it forms the silicates, and is the most common of all minerals. It has a large number of distinct forms that are classed as varieties of the same species under the general name Quartz. It usually occurs in six-sided prisms, terminated by six-sided prisms. Also occurs granular and massive.

2. *Phys.* *a.* Lustre, vitreous. Has no apparent cleavage.

b. Colorless and limpid, or variously colored, forming many varieties.

c. It may possess every degree of transparency.

3. *Chem.* Infusible. Insoluble except in hydrofluoric acid.

4. *Diag.* Distinguished by the form of its crystals, its hardness, and in not being attacked by ordinary acids.

5. *Varieties.* The varieties of Quartz may be divided into two general classes, Phenocrystalline and Cryptocrystalline. These varieties are arranged as follows, showing the name and distinguishing characteristics of each.

I. Phenocrystalline.

(1) Rock crystal. Pure transparent crystal quartz. It is found in the veins of rocks in the interior of geodes, &c. Used for jewelry and for optical instruments.

(2) Amethyst. A violet variety colored by the oxide of manganese.

(3) Rose Quartz. The color of the rose. Rarely crystallized. Color fades on exposure to the light.

(4) Ferruginous Quartz. A yellowish-brown variety, colored by the oxide of iron. Generally crystallized.

(5) Milky Quartz. Milk white. Opaque, or nearly so. Generally massive. Common.

(6) Smoky Quartz. A smoky variety of quartz crystal.

II. Cryptocrystalline.

(1) Chalcedony. A translucent massive variety, with the lustre of wax.

(2) Carnelian. A clear red chalcedony.

(3) Prase. A dull-green massive quartz.

(4) Chrysophrase. An apple-green chalcedony.

(5) Agate. A variegated chalcedony. Moss agate has yellow or brownish moss-like forms, caused by the oxide of iron.

(6) Jasper. Opaque colored quartz. Frequently in globular masses. Colored by the peroxide of iron.

(7) Flint. Opaque chalcedony, colored grayish blue or black by the presence of carbon. Found in the limestone and chalk formations.

6. *Obs.* Fine specimens of quartz are found at Paris, Me., Berkshire and Chesterfield, Mass., and elsewhere. Flint is said to be formed from infusorial shells. Rock crystal is extensively used in the manufacture of glass. Fragmentary quartz is called sand.

OPAL.

Composition same as quartz, but containing 5 to 20% of water.

H. 5.5–6.5 Sp. Gr. 2–2.3.

1. *Occ.* It is a dimorphous variety of quartz. It is generally found in the cavities or clefts of volcanic rocks, and is the product of exfiltration.

2. *Phys.* *a.* Lustre, vitreous, resinous or pearly.
b. Colorless or variegated, with a rich play of colors. Streak, white.

c. Transparent to opaque.

3. *Chem.* It is soluble in the alkalies (potash ley), which distinguishes it from quartz. Infusible. Colors in acids.

4. *Diag.* Distinguished by its chemical reactions.

5. *Obs.* It is used for gems, some of which are very rare. Precious opal has a milky color and a fine play of rich tints. Fire opal has bright yellow or fire-red reflections. There are several varieties not mentioned here. It occurs disseminated through limestone rocks; and is found in Hungary and the Faroe Islands. Impure varieties are found in several places in the U. S. Fine specimens have been obtained from the feldspar mines at Topsham, Me.

CHAPTER IX.

TERNARY COMPOUNDS.

SULPHATES.

GYPSUM.. $\begin{cases} \text{Lime, 33.} \\ \text{Sulphuric Acid, 46.} \\ \text{Water, 21.} \end{cases}$

Calcium Sulphate (hydrous).

Monoclinic System.

H. 1.5–2. Sp. Gr. 2.5–3.

1. *Occ.* It crystallizes in the oblique rhombic prism. Primitive form rare.

Frequently forms twin crystals. Also occurs in

laminated masses, fibrous, radiating, granular and compact.

It is sometimes found as an independent rock, and in mines as a recent product.

2. *Phys.* *a.* Lustre, subvitreous, pearly.
b. Color, white, gray, flesh-red, yellow.
c. Streak, white.
d. Cleavage, easy, often perfect.
e. Laminar, flexible, inelastic.

3. *Chem.* Before the blowpipe it becomes instantly white, swells and exfoliates, then falls to a powder which fuses in a high heat.

No action with acids.

4. *Diag.* Is readily distinguished by its softness and peculiar blowpipe reactions.

5. *Obs.* There are several varieties of this mineral. A transparent foliated variety is called selenite.

Latin Spar is white, fibrous, with delicate satin lustre.

Alabaster is the fine-grained, compact variety, and is cut into vases and other ornaments.

Gypsum, when burnt and ground, is called Plaster of Paris. The mineral is also ground and used as a fertilizer. It is found abundantly in Middl and Western States. It occurs at Mammoth Cave in the form of rosettes, stalactites and other fanciful forms.

BARITE.. { Barium, 65.
Sulphuric Acid, 35.

Barium Sulphate.

Orthorhombic System.

H. 3. Sp. Gr. 4.5.

1. *Occ.* Its crystal is the right rhombic prism, usually modified and tabular.

It also occurs lamellar, fibrous, granular and compact.

Barite is often associated with the ores of metals and seldom forms independent rocks.

2. *Phys.* *a.* Lustre, vitreous, bright.
b. Color, white, yellow, brown and red.
c. Streak, uncolored.
d. Transparent, translucent, opaque.
e. Cleavage, easy and sometimes perfect.

3. *Chem.* Before the blowpipe decrepitates and fuses with difficulty. Colors the flame yellowish green. Is not affected by acids.

4. *Diag.* It is distinguished from celestine and aragonite by its higher specific gravity; from the various carbonates by not effervescing with acid, and from metallic minerals by giving no metallic action before blowpipe.

5. *Obs.* This mineral is much used to adulterate white lead. This mixture is often preferable, as the paint is not blackened so quickly by sulphurous vapors.

Barite is ground for this purpose at Hatfield, Mass., and other places. It is also called Heavy Spar and Barites.

CELESTINE.. { Strontium, 56.
Sulphuric Acid, 44. }

Strontium Sulphate.

Orthorhombic System.

H. 3 - 3.5. Sp. Gr. 3.92 - 3.97.

1. *Occ.* Primitive form is the right rhombic prism. Also granular, fibrous or massive.

2. *Phys.* *a.* Lustre, vitreous to resinous.
b. Colorless, limpid or with bluish tinge.
c. Streak, white.
d. Fracture, lamellar or conchoidal.

3. *Chem.* Decrepitates, fuses and colors the flame red. Insoluble.

4. *Diag.* Distinguished from barite by the long, slender crystals and lower specific gravity; from the carbonates by not effervescing with acids.

5. *Obs.* It resembles lamellar barite, but may be distinguished as above.

The nitrate of strontium used in fireworks is made from this mineral.

NATIVE ALUM.

Potassium and Aluminum Sulphate.

Isometric System.

H. 2-2.5. Sp. Gr. 1.6 - 1.9.

1. *Occ.* Crystallizes usually in octahedrons, also occurs in fibrous masses.

2. *Phys.* *a.* Lustre, vitreous. Fracture conchoidal.

b. Colorless. Transparent to translucent.

c. Taste, sweet-astringent.

d. Soluble in water.

3. *Chem.* Fuses in its waters of crystallization.

4. *Diag.* Distinguished by its sweetish-astringent taste.

5. *Obs.* The varieties have different bases and are known as Soda-Alum, Magnesia-Alum, Iron-Alum, Manganese-Alum, and Ammonia-Alum. Potash-Alum is the alum of commerce; its composition is represented above. The composition in all the varieties is 1 for each of the sulphates to 24 parts of water.

Thus the ratio for alum here described is Potassium Sulphate 1, Aluminum Sulphate 1, Water 24.

PHOSPHATES.

PYROMORPHITE.. { Lead, 78.
Phosphoric Acid, 16.
Chlorine, 6.

Lead Phosphate.

Hexagonal System.

H. 3.5–4.5. Sp. Gr. 6.5–7.1

1. *Occ.* It crystallizes in hexagonal prisms. Cleavage lateral. It has also a reniform and radiated structure. Sometimes occurs massive.

2. *Phys.* *a.* Lustre, resinous, adamantine.

b. Colors are variable, green, yellow, brown or white.

c. Translucent, opaque.

d. Streak, white or yellowish.

3. *Chem.* Fuses easily; reduces to a globule of lead.

Soluble with difficulty.

4. *Diag.* Distinguished by its high specific gravity and blowpipe characters.

5. *Obs.* The different colors indicate a variety of compositions.

It is a valuable ore of lead and is found at Lubec, Me., Southampton, Mass., and elsewhere.

APATITE.. { Lime, 54. Phosphoric Acid, 42. Fluorine, 4. }

Calcium Phosphate.

Hexagonal System.

H. 4.5–5. Sp. Gr. 3–3.2.

1. *Occ.* Crystallizes in hexagonal prisms and has an imperfect cleavage. Sides of the prisms often striated. Sometimes occurs massive.

2. *Phys.* *a.* Luster, vitreous to resinous.
b. Color, green, yellowish green or white.
c. Brittle. May be scratched with a knife.

3. *Chem.* Infusible. Soluble in nitric acid.

4. *Diag.* It is less hard than beryl. Does not effervesce in acids, which distinguishes it from the carbonates. Its infusibility distinguishes it from other metallic species.

5. *Obs.* Apatite occurs in mica schist, gneiss and granular limestone.

Fine specimens have been found at St. Lawrence

County, N. Y., and at Westmoreland, N. H.; also occurs at Chester and Boston, Mass.

It is extensively used as a fertilizer.

TRIPLITE.. { Manganese, 33. Phosphoric Acid, 33. Iron and Calcium, 34.

Manganese Phosphate (*ferruginous*).

Orthorhombic System.

H. 4.5-5. Sp. Gr. 3.4.-3.8.

1. *Occ.* Generally massive.

2. *Phys.* *a.* Lustre, resinous. Opaque.
   b. Color and streak, blackish brown.
   c. Very fragile.

3. *Chem.* Fuses readily to a black globule. Soluble in chlorhydric acid.

4. *Diag.* Distinguished by its color and lustre.

5. *Obs.* It is the common phosphate of manganese. Found abundantly at Washington, Conn., and sparingly at Sterling, Mass.

CARBONATES.

CERUSSITE.. { Lead, 84. Carbonic Acid, 16.

Lead Carbonate.

Orthorhombic System.

H. 3-3.5. Sp. Gr. 6.4.

1. *Occ.* Crystallizes in right rhombic prisms, usually modified. Also massive, rarely fibrous. Generally found in the outcrops of veins. Associated with galenite.

2. *Phys.* *a.* Lustre, adamantine.
b. Color, white, gray, blue and green.
c. Streak, white.
d. Fracture, conchoidal; very brittle.

3. *Chem.* Before blowpipe decrepitates and gives a metallic globule. Soluble with effervescence in dilute nitric acid.

4. *Diag.* Resembles Anglesite, but is distinguished by its acid reaction. Characterized by its high specific gravity.

5. *Obs.* This is a valuable ore of lead. It is the white lead of commerce, which is at present, however, artificially produced. It was formerly regarded as useless.

It is abundant in the mines of the Mississippi Valley. Specimens are found in Southampton, Mass.

AZURITE.. { Copper, 70.
Carbonic Acid, 30.

Copper Carbonate (blue).

Monoclinic System.

H. 3.5–4.2. Sp. Gr. 3.5–3.8.

1. *Occ.* Generally occurs massive or in minute aggregated crystals.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, azure blue.
c. Translucent, opaque.
d. Streak, bluish.

3. *Chem.* Same as Malachite.

4. *Diag.* Distinguished from Vivianite by blowpipe characters, and in general by its sky-blue color.

5. *Obs.* It occurs with the other ores of copper, and when abundant is a valuable ore.

MALACHITE.. { Copper, 72.
Carbonic Acid, 28.

Copper Carbonate (*green*).

Monoclinic System.

H. 3.5–4. Sp. Gr. 3.7–4.

1. *Occ.* Crystals are quite rare. Usually occurs in botryoidal masses.

2. *Phys.* *a.* Lustre, silky, dull or earthy. The crystals are sometimes vitreous or adamantine.

b. Color, different shades of green.

c. Translucent to opaque. Streak, pale green.

3. *Chem.* Fuses readily and reduces to a globule of copper. Soluble in acids with effervescence.

4. *Diag.* Distinguished from Chrysocolla by its copper-green color and effervescing with acids.

5. *Obs.* It is an important ore of copper. It receives a high polish and is used for inlaid work and articles of ornament. It is found in small quantities in copper mines. A mass weighing forty tons was found in Siberia.

SIDERITE... { Iron, 62.
Carbonic Acid, 38.

Iron Carbonate.

Hexagonal System.

H. 3.5–4. Sp. Gr. 3.8.

1. *Occ.* It crystallizes in rhombohedra, generally with curved faces. Often massive, foliated.

2. *Phys.* *a.* Lustre, pearly, vitreous.
b. Color, light gray to brown.
c. Streak, colorless.
d. Translucent to nearly opaque.
e. Turns black on exposure.

3. *Chem.* Blackens before blowpipe, fuses with difficulty, and becomes magnetic. Soluble in acids, with slow effervescence.

4. *Diag.* It is distinguished from Dolomite and Calcite by its higher specific gravity, from Sphalerite by the action of acids.

5. *Obs.* This is one of the most useful ores of iron. It is known as Spathic Iron and Chalybite. It is found at Sterling, Mass., and is very abundant in the Pennsylvania coal regions.

SMITHSONITE.. { Zinc, 65. Carbonic Acid, 35.

Zinc Carbonate.

Hexagonal System.

H. 5. Sp. Gr. 4–4.5.

1. *Occ.* Crystallizes in rhombohedra. It generally occurs massive, reniform or stalactitic.

2. *Phys.* *a.* Lustre, vitreous or pearly. Fracture uneven.
b. Color, white, yellow, green or brown.
c. Streak, white. Transluc. Brittle.

3. *Chem.* Infusible. Efferversces slowly in cold acids, more readily in hot.

4. *Diag.* Distinguished by its hardness, difficult fusibility, and zinc fumes from other carbonates.

5. *Obs.* Occurs with galenite, and usually in calcareous rocks.

It is found in Missouri, Iowa, Wisconsin and Tennessee.

CALCITE.. { Lime, 56. Carbonic Acid, 44.

Calcium Carbonate.

Hexagonal System.

H. 2.5-3.5. Sp. Gr. 2.5-2.7.

1. *Occ.* It has a great variety of forms. Crystals are usually rhombohedral. Also occurs in granular masses.

2. *Phys.* *a.* Lustre, vitreous or earthy.
   b. It is usually white, or may be various colors. Streak white.
   c. It has the power of double refraction. Cleavage easy and parallel to the fundamental rhombohedron.

3. *Chem.* Infusible. Gives a luminous flame, and burns to quicklime. Effervesces strongly with acids.

4. *Diag.* All the varieties may be scratched with a knife, and effervesce rapidly with acids, by which characters they may be distinguished.

5. *Obs.* Next to quartz, calcite is most commonly found in nature. It has many varieties, viz.: —

(1) Iceland Spar. Transparent crystalline variety that shows double refraction.

(2) Satin Spar. Fine, fibrous, with silky lustre.

(3) Chalk. White, earthy, lustreless, soft.

(4) Stalactite. Found hanging in cylinders from the roofs of caverns. Deposited on the floors of caverns the same mineral is called Stalagmite.

(5) Limestone. The massive varieties are classed under the general name of limestones.

The Quicklime of commerce is obtained from this mineral. The various marbles are varieties.

ARAGONITE.. { Lime, 56. Carbonic Acid, 44.

Calcium Carbonate.

Orthorhombic System.

H. 3.5 - 4. Sp. Gr. 2.9.

1. *Occ.* Crystals usually columnar, inclining to twin forms. Singly imbedded or clustered in grades; also in fibrous seams.

It occurs as an accessory in clay, gypsum and iron deposits; also in volcanic rocks.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, white, gray, yellow, green.
c. Streak, white.
d. Fracture, scaly or conchoidal
e. Transparent, translucent.

3. *Chem.* Before blowpipe it decrepitates and falls to a white powder.

Soluble in acids with effervescence.

4. *Diag.* It resembles calcite very much, but is distinguished by its want of cleavage and blow-

pipe reaction. Differs from Witherite and Strontianite in specific gravity, from Barite and Celestite in blowpipe behavior.

5. *Obs.* Coral-like forms occur in iron beds and are known as Flos-ferri.

Aragonite, also called Aragon Spar, is found in Aragon, Spain, at Lockport, N. Y., and Chester County, Penn.

DOLOMITE.. { Calcium Carbonate, 54.
Magnesium Carbonate, 46.

Calcium and Magnesium Carbonate.

Hexagonal System.

H. 3.5 – 4. Sp. Gr. 2.8 – 2.9.

1. *Occ.* Crystallizes in rhombohedra. Often granular and massive. Cleavage perfect; faces generally curved.

2. *Phys.* *a.* Lustre, vitreous or pearly.
b. Color, usually white or grayish.
c. Transparent to translucent.
d. Brittle.

3. *Chem.* Infusible. Effervesces when powdered and heated.

4. *Diag.* Appears like Calcite but effervesces more slowly, and is a little harder.

5. *Obs.* Massive Dolomite occurs common in the New England States, and constitutes a large portion of the coarse marble used in building. It is called Magnesian Limestone. It feels more coarse and rough to the hand, and is more brittle than the common limestone. It is used in the manufacture of Epsom salts.

WITHERITE.. { Baryta, 78. Carbonic Acid, 22.

Barium Carbonate.

Orthorhombic System.

H. 3.5. Sp. Gr. 4.3.

1. *Occ.* The primitive form, the right rhombic prism, is seldom found. Usually hexagonal; also massive in fibrous, granular or globular forms.

2. *Phys.* *a.* Lustre, resinous.
b. Color, white, gray or yellow.
c. Streak, white.
d. Fracture, scaly.
e. Transparent or translucent.

3. *Chem.* It decrepitates before blowpipe and fuses, giving the flame a yellow-green color.

With acid it effervesces slowly, and dissolves when heated.

4. *Diag.* It is distinguished from Calcite and Aragonite by its fusibility, from Strontianite by its green flame before blowpipe, and from metallic ores by yielding no metal.

5. *Obs.* The salts of barium are prepared from this mineral; they are much used in analysis and the nitrate in pyrotechny.

Barium carbonate is used as a poison, and is artificially prepared as a water color.

The mineral is very abundant in Cumberland and Lancashire, England.

STRONTIANITE.. { Strontia, 70. Carbonic Acid, 30.

Strontium Carbonate.

Orthorhombic System.

H. 3.5 – 4. Sp. Gr. 3.6 – 3.7.

1. *Occ.* In right rhombic prisms. Cleavage distinct. Generally found massive.

2. *Phys.* *a.* Lustre, vitreous or resinous.
b. Color, grey, white, usually with a tinge of green.
c. Transparent to translucent.

3. *Chem.* Infusible. With chlorhydric acid it tinges flame crimson. Effervesces with acids.

4. *Diag.* Its effervescence distinguishes it from the non-carbonates. Its deep crimson flame from Witherite and Calc Spar.

The coloring for fireworks is obtained from this mineral as well as from Celestine.

NATRON . . . { Soda, 19. Carbonic Acid, 27. Water, 54.

Sodium Carbonate (*hydrous*).

Monoclinic System.

H. 1 – 1.5. Sp. Gr. 1.4.

1. *Occ.* Is usually found in white, chalky masses in which crystals may be seen.

2. *Phys.* *a.* Lustre, vitreous or earthy.
b. Color, white.
c. Taste, alkaline.
d. Effloresces on exposure, and falls to dust.

3. *Chem.* Before blowpipe gives up water and fuses. Soluble in water, and with great effervescence in acid.

4. *Diag.* Readily distinguished by its effervescence and its efflorescence on exposure.

5. *Obs.* This mineral abounds in certain lakes of Northern Africa; is also found in Mexico and elsewhere.

It is largely used in the manufacture of soap, and in Mexico for a flux in reducing silver ores.

MAGNESITE.. { Magnesia, 48. Carbonic Acid, 52.

Magnesium Carbonate.

Hexagonal System.

H. 3.5–4.5 Sp. Gr. 3.

1. *Occ.* It crystallizes in rhombohedra. Is generally found crystallized, but sometimes fibrous, granular and compact.

2. *Phys.* *a.* Lustre, vitreous; fibrous variety, silky.
b. Color, white, yellow or brown.
c. Transparent, opaque.
d. Fracture, conchoidal or flat.

3. *Chem.* It is infusible but glows intensely. Dissolves slowly with slight effervescence in acid.

4. *Diag.* It is distinguished from lime carbonates by its feeble effervescence, and from Dolomite, which it closely resembles, by its easier solubility.

5. *Obs.* This mineral is found at Bolton and Lynnfield, Mass., and is much used for making Epsom Salts — Magnesium Sulphate.

SILICATES.

CHRYSOCOLLA.. { Copper, 46. Silicic Acid, 34. Water, 20.

Copper Silicate (hydrated).

H. 2–4. Sp. Gr. 2–2.4.

1. *Occ.* Usually occurs in incrustations, in large masses, or botryoidal. Never occurs in crystals.

2. *Phys.* *a.* Lustre, resinous, vitreous and shining.
b. Color, bluish green or sky-blue. Sometimes brown or black.
c. Translucent, opaque.

3. *Chem.* Infusible. Colors flame green. Soluble in acids, or partly so.

4. *Diag.* Distinguished from green malachite by not effervescing in acids.

5. *Obs.* It is associated in large masses with other ores of copper, but is generally impure, yielding from 10 to 30% of copper. It is a valuable ore, and is abundant in the Mississippi Valley.

CALAMINE .. { Zinc, 70. Silicic Acid, 30.

Zinc Silicate.

Orthorhombic System.

H. 4.5–5. Sp. Gr. 3.3–3.4.

1. *Occ.* In modified rhombic prisms, also massive or stalactitic.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, whitish, bluish to brownish.

c. Streak, uncolored.
d. Transparent to translucent.
e. Brittle.

3. *Chem.* Infusible alone. Soluble in hot sulphuric acid.

4. *Diag.* Distinguished from Aragonite and Calcite by its action with acids.

Does not effervesce.

5. *Obs.* It is a valuable ore of zinc. It is found at Wythe County, Va., and at Friedersville, Penn.

ZIRCON.. { Zirconium, 67. Silicic Acid, 33.

Zirconium Silicate.

Tetragonal System.

H. 7.5. Sp. Gr. 4.5.

1. *Occ.* Zircon is always crystallized. It is frequently found disseminated in some of the older rocks.

2. *Phys.* *a.* Lustre, adamantine.
b. Color, white, brownish red in clear tints.
c. Streak, colorless.
d. Fracture, conchoidal, brilliant.
e. Transparent to opaque.

3. *Chem.* Infusible. Insoluble.

4. *Diag.* It resembles garnet but is distinguished by its crystals and hardness; differs from Tourmaline, Vesuvianite and Staurolite in its hardness and infusibility.

5. *Obs.* The clear crystals are of common use

in jewelry; they are called hyacinths. The hyacinth of commerce, however, is, to a large extent, cinnamon stone, a variety of garnet.

Zircon is also used in jewelling watches. Ceylon, Siberia and Greenland are the chief localities. It occurs in Nova Scotia, Pennsylvania, and at Litchfield, Maine.

RHODONITE.. { Manganese, 54. Silicic Acid, 46.

Manganese Silicate.

Triclinic System.

H. 5.5 – 6.5. Sp. Gr. 3.5.

1. *Occ.* Crystals rarely perfect. Is found in masses, and is often broken up into pyramidal shapes.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, brownish red, greenish or yellowish.
c. Streak, white.
d. Transparent, opaque.
e. Very tough when massive.

3. *Chem.* Blackens and fuses with slight intumescence.

Partially soluble in acids.

With borax gives a violet glass which is the characteristic of the ores of Manganese.

4. *Diag.* Is distinguished from a flesh-red Feldspar by its greater specific gravity.

Differs from the carbonate of Manganese (Rhodocrosite) by its greater hardness.

5. *Obs.* This mineral is found in masses at

Plainfield and Cummington, Mass., at Blue Hill Bay, Me., and elsewhere.

It is generally called Manganese Spar.

Varieties are Fowlerite and Bustamite.

PYROXENE.. { The bases are variable. Silicic Acid, 55 (?).

A Silicate of Lime, Magnesia, Alumina or Iron.

Monoclinic System.

H. 5 – 6. Sp. Gr. 3.5.

1. *Occ.* It crystallizes in oblique rhombic prisms. Also occurs in stalk-like, scaly or granular masses. Is found in granite, limestone, serpentine, basalt and lavas.

2. *Phys.* *a.* Lustre, vitreous.
   b. Color, white to black through green and blue shades, but never yellow.
   c. Streak, white, gray or greenish.
   d. Transparent to opaque, brittle.

3. *Chem.* Fuses to a white, gray, green or black glass. Imperfectly decomposed by acids.

4. *Diag.* It is distinguished from Hornblende by its cleavage, parallel with the diagonals; from Amphibole by its crystals; from Epidote by its color.

5. *Obs.* Pyroxene is one of the commonest minerals. It is found in many places in New York, and at Raymond and Rumford, Maine.

The black varieties are called Augite. The colorless varieties Malacolite or Diopside.

Decomposed, capillary crystals of Pyroxene and Amphibole are called Asbestus.

SEPIOLITE.. { Magnesia, 27. Silicic Acid, 61. Water, 12.

Magnesium Silicate (hydrous).

Always Massive.

H. 2–2.5. Floats on water.

1. *Occ.* It occurs between beds of lime and clay. It is sometimes found porous, lamellar and impure.

2. *Phys.* *a.* Dull and without lustre.
b. Color, white, greyish, yellowish or reddish.
c. Opaque. Has a greasy feel.

3. *Chem.* Infusible. Effervesces slightly with acids.

4. *Diag.* Distinguished by its softness, lightness and greasy feel.

5. *Obs.* It appears nearly like clay. It is prepared for the bowls of pipes by a process similar to that for pottery ware.

It is generally found in Greece and Asia Minor.

It is the Meerschaum or Sea Froth of commerce.

TALC.. { Magnesia, 33. Silicic Acid, 63. Water, 4.

Magnesium Silicate (hydrous).

Orthorhombic System.

H. 1–1.5. Sp. Gr. 2.5–2.8.

1. *Occ.* Crystallizes in right rhombic or hexagonal prisms. Usually occurs in pearly foliated

masses. Separates easily into thin folia. Often massive or in pearly scales.

2. *Phys.* *a.* Lustre, very pearly. Has a greasy feel.
b. Color, green-gray or silvery white.
c. Streak, white. Translucent. It is flexible, but not elastic.

3. *Chem.* Fuses with difficulty on the thin edges. Whitens and swells. Insoluble.

4. *Diag.* It is distinguished by its soapy feel, foliated structure and pearly lustre.

5. *Obs.* Soapstone is a gray, massive variety. A slaty variety is known as Talcose Schist. It is used for heating purposes, and when powdered, as a lubricator. Occurs abundantly at Middlefield, Mass., Dexter, Me., and elsewhere.

CYANITE.. $\begin{cases} \text{Alumina, 63.} \\ \text{Silicic Acid, 37.} \end{cases}$

Aluminum Silicate.

Triclinic System.

H. 5–7. Sp. Gr. 3.6.

1. *Occ.* It crystallizes as a doubly inclined rhombic prism. It is generally found in long thin fibrous crystals joined together parallel to each other or radiating from a common centre. It is associated with Mica and Quartz.

2. *Phys.* *a.* Lustre, vitreous or pearly.
b. Color, usually blue, sometimes grey, green and even black.
c. Streak, colorless.
d. Transparent to opaque.

e. Somewhat brittle.

3. *Chem.* Infusible. Colored varieties become white. Not acted on by acids.

4. *Diag.* Can usually be recognized by its blue blue color and fibrous crystals.

Differs from amphibole in its infusibility.

5. *Obs.* This mineral occurs at Westfield and Chesterfield, Mass., and elsewhere.

It is sometimes used as a gem to imitate Sapphire.

The white varieties have the name of Rhartizite. The mineral is sometimes spelled Kyanite.

ANDALUSITE.. { Alumina, 63. Silicic Acid, 37.

Aluminum Silicate.

Orthorhombic System.

H. 7.5. Sp. Gr. 3.2.

1. *Occ.* It crystallizes as a right rhombic prism. It also occurs massive and coarse columnar, but never fine or fibrous. Found in granite and gneiss.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, gray and flesh-red; sometimes greenish.
c. Streak, colorless.
d. Translucent to opaque.
e. Tough.

3. *Chem.* Infusible. Insoluble in acids.

4. *Diag.* It is distinguished from Pyroxene, Scapolite and Feldspar by its infusibility.

5. *Obs.* A peculiar disposition of Andalusite is called Chiastolite or Macle. In this form various

impurities are disseminated regularly along the sides, edges and diagonals of a crystal, which therefore shows a tesselated or cruciform structure when broken across and polished.

Andalusite is found at Bangor, Me., Westford and Lancaster, Mass.

ALBITE.. { Soda, 12. Alumina, 19. Silicic Acid, 69.

Sodium and Aluminum Silicate.

Triclinic System.

H. 6-7. Sp. Gr. 2-6.

1. *Occ.* Its regular crystal is the oblique rhombic prism, but simple crystals are rare. Usually it is found in collections of crystals united to form one large one. It also occurs massive, with a granular or lamellar structure.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, usually white or milky, also reddish green, bluish and gray.
c. Streak, colorless.
d. Fracture, lamellar.
e. Transparent, translucent, brittle.

3. *Chem.* Fuses to a clear bead, coloring flame yellow — the test for Natrium. Insoluble in acids.

4. *Diag.* Its general characteristic is its whiteness.

5. *Obs.* Albite is found in a number of rocks replacing Orthoclase, as in granite and porphyry. Albite granite is lighter in color than Feldspar granite, and often contains rare minerals and gems.

Albite is also called Cleavelandite, and a milky-white variety with a very bright lustre is known as Pericline.

ORTHOCLASE.. { Potassa, 16. Alumina, 19. Silicic Acid, 65.

Potassium and Aluminum Silicate.

Monoclinic System.

H. 6. Sp. Gr. 2.5.

1. *Occ.* Its crystal is like Albite. The simple form is rare. Usually crystalline, massive.

It occurs in extensive beds in granite regions, where it has been derived from the decomposition of this rock.

2. *Phys.* *a.* Lustre, vitreous, pearly on cleavage faces.

b. Color, usually colorless; sometimes flesh-red and green.

c. Streak, uncolored.

d. Fracture, lamellar.

e. Transparent, translucent, opaque.

3. *Chem.* The colored varieties whiten before blowpipe. In thin scales it fuses to a white glass. Not acted on by acids.

4. *Diag.* Differs from Albite in containing Potassium and in the usual absence of Sodium.

5. *Obs.* The green variety of this mineral is used for ornaments under the name of Amazon Stone.

A transparent variety found among volcanic products is called Sanidine.

Moonstone is an opalescent variety, with pearly reflections.

Orthoclase is one of the constituents of granite, gneiss, mica slate, porphyry and basalt. It is found wherever these rocks occur, is used largely in the manufacture of porcelain, and is generally called Feldspar. It is quarried extensively in Topsham, Me.

LEUCITE . . . { Potassa, 21. Alumina, 24. Silicic Acid, 55.

Potassium and Aluminum Silicate.

Isometric System.

H. 5.5 – 6. Sp. Gr. 2.5.

1. *Occ.* Is always found crystallized, generally in lavas.

2. *Phys.* *a.* Lustre, vitreous to dull.
b. Color, white, gray, reddish white.
c. Streak, colorless.
d. Crystals sometimes transparent, usually opaque.

3. *Chem.* Infusible. Soluble.

4. *Diag.* It is distinguished from Analcite by its infusibility.

5. *Obs.* It abounds in the lavas of Italy. When large crystals are broken across it is found that the outside only is Leucite, the interior being filled with lava.

BERYL . . { Glucinum, 14. Aluminum, 9. Silicic Acid, 67.

Glucinum and Aluminum Silicate.

Hexagonal System.

H. 7.5 – 8. Sp. Gr. 2.7.

1. *Occ.* Its crystal is the hexagonal prism. Always in crystals or crystalline. It is found in granite and gneiss.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, green, blue, yellow or colorless. Rarely red.
c. Streak, dull white.
d. Fracture, conchoidal, uneven.
e. Brittle.

3. *Chem.* Before blowpipe fuses with difficulty on edges. Not affected by acids. Colored varieties become white when heated.

4. *Diag.* Is distinguished from Apatite and Tourmaline by its greater degree of hardness; from Topaz and Euclase by its imperfect cleavage; from Quartz by its cleavage and fracture.

5. *Obs.* The finer crystals are used as gems. Emerald is a rich green variety which may owe its fine color to chromium oxide. The sea-green and pale-bluish-green varieties are known to jewellers as aqua marine.

The crystals of Beryl are sometimes enormous; one from Grafton, N. H., weighed 2900 lbs., and another 1076 lbs.

The finest emeralds come from Muso in New Granada. The finest beryls come from Siberia, Hindostan and Brazil. Transparent crystals seldom occur in the U. S. Specimens are found at Grafton,

N. H., Barre and Fitchburg, Mass., Topsham and Bowdoinham, Maine.

NEPHELITE.. { Soda, 17.
Potassa, 5.
Alumina, 34.
Silicic Acid, 44.

Sodium, Potassium and Aluminum Silicate.

Hexagonal System.

H. 5.5–6. Sp. Gr. 2.4–2.6.

1. *Occ.* It has the form of the hexagonal prism. Generally occurs massive.

2. *Phys.* *a.* Lustre, vitreous or greasy.
b. Color, greenish, bluish or yellowish.
c. Transparent to opaque.

3. *Chem.* Fuses to a colorless glass.

4. *Diag.* Distinguished by its greasy lustre from Wernerite and Feldspar.

5. *Obs.* When this mineral occurs in cleavable masses of a greasy-green color, it is known as Elæolite. The yellow variety at Litchfield, Me., where it occurs, is known as Cancrinite.

A deep-blue variety in which the chloride of sodium take the place of potash in the composition, is called Sodalite.

These minerals, with Zircon, are associated in the Nephelite rock in West Gardiner, Me. This class of minerals is very rare.

STILBITE.. { Lime, 9.
Alumina, 17.
Silicic Acid, 57.
Water, 17.

Calcium and Aluminum Silicate (hydrous).

Orthorhombic System.

H. 3.5–4. Sp. Gr. 2.2.

1. *Occ.* Its crystal is the rhombic prism. The crystals are frequently clustered in sheaves or bundles. It is also massive, fibrous.

2. *Phys.* *a.* Lustre, vitreous, pearly.
b. Color, white; sometimes yellow or brown.
c. Streak, colorless.
d. Translucent to opaque.
e. Fracture, uneven.

3. *Chem.* Before blowpipe it swells and finally fuses to a white enamel. Soluble in acids.

4. *Diag.* It is distinguished from Gypsum by its hardness; from Heulandite by the thinness of its crystals; from Antimony Oxides by blowpipe reaction.

5. *Obs.* It is found in the Syenite quarries at Chester and Charlestown, Mass., also at Lake Superior and in New York.

It is found in fissures and cavities of volcanic rocks and in metalliferous veins. It belongs to the Zeolite group.

PREHNITE.. { Lime, 27.
Alumina, 25.
Silicic Acid, 44.
Water, 4.

Calcium and Aluminum Silicate (hydrous).

Orthorhombic System.

H. 6–6.5, Sp. Gr. 2.9.

1. *Occ.* Its crystal is the right rhombic prism, which rarely occurs. Usually complex. Often reniform, botryoidal. In trap, gneiss and granite.

2. *Phys.* *a.* Lustre, vitreous; on cleavage face pearly.
   b. Color, green to white.
   c. Streak, colorless.
   d. Transparent to translucent.

3. *Chem.* Fuses with intumescence. Is decomposed with acids.

4. *Diag.* Differs from Beryl in its infusibility; from the Zeolites in its greater hardness; from green quartz in its solubility.

5. *Obs.* Prehnite is found at Somerville, Mass., and elsewhere. It is sometimes used for ornamental work. It is found with the Zeolites, but does not belong to that family.

VESUVIANITE.. { Lime, 30. Alumina, 23. Silicic Acid, 37. Magnesium and Iron, 10.

Calcium and Aluminum Silicate.

Tetragonal System.

H. 6.5. Sp. Gr. 3.4.

1. *Occ.* It crystallizes as a square prism, usually modified. Also occurs in granular, lamellar and sub-columnar masses.

2. *Phys.* *a.* Lustre, vitreous to resinous.
   b. Color, green, reddish brown and yellow.
   c. Streak, uncolored.

d. Fracture, smooth, conchoidal, sometimes uneven.

e. Translucent, opaque.

3. *Chem.* Fuses with intumescence to a yellow globule. It is only partially attacked by acids.

4. *Diag.* Differs from Epidote in its crystal, and is much more fusible; from Pyroxene it differs in color; from Garnet by the presence of water.

5. *Obs.* This mineral was first found in the lavas of Vesuvius; from this circumstance it has been called Vesuvianite and Vesuvian. It was formerly known as Idocrase. It is found in Norway and Siberia. Rumford, Me., and Worcester, Mass., are New England localities. It is sometimes cut as a gem. A blue variety colored by copper is known as Cyprine.

WERNERITE.. { Soda, 5. Lime, 18. Alumina, 29. Silicic Acid, 48.

Sodium, Calcium and Aluminum Silicate.

Tetragonal System.

H. 5–6. Sp. Gr. 2.7.

1. *Occ.* It crystallizes in square prisms, usually modified. Also massive, lamellar and subfibrous. It is found in the older crystalline rocks.

2. *Phys.* *a.* Lustre, vitreous to resinous.

b. Color, white, gray, bluish, greenish, reddish.

c. Streak, uncolored.

d. Transparent to nearly opaque.

3. *Chem.* Fuses easily with intumescence. Is decomposed by acids.

4. *Diag.* When crystallized, it is readily distinguished from the Feldspars by its form; when massive, by its intumescence before blowpipe.

5. *Obs.* It is found at Bolton and Westfield, Mass., also in New York, Connecticut and Vermont. Its more common name is Scapolite.

LABRADORITE.. { Soda, 5. Lime, 12. Alumina, 30. Silicic Acid, 53.

Sodium, Calcium and Aluminum Silicate.

Triclinic System.

H. 6. Sp. Gr. 2.7.

1. *Occ.* It has the same forms and cleavages as the other Feldspars. It is usually found in cleavable massive forms, highly striated. It is a constituent of some granites.

2. *Phys.* *a.* Lustre, vitreous, pearly on the base.
b. Color, gray, brown or greenish.
c. Streak, colorless.
d. Translucent. Opaque.
e. It usually shows a bright play of colors on a cleavage face.

3. *Chem.* Fuses to a colorless glass. Is dissolved by chlorhydric acid, and when it has been reduced to a fine powder it gelatinizes.

4. *Diag.* It differs from the other Feldspars in its solubility in acids.

Its chief characteristic is its play of colors.

5. *Obs.* This mineral receives a fine polish and is sometimes set in jewelry.

It was originally found in Labrador. It occurs in various localities in Nova Scotia and Maine.

NATROLITE.. { Soda, 16. Alumina, 27. Silicic Acid, 47. Water, 10.

Sodium and Aluminum Silicate (hydrous).

Orthorhombic System.

H. 5 – 5.5. Sp. Gr. 2.2.

1. *Occ.* Is found in right rhombic prisms; also in fibrous masses radiating from a centre. Usually crystallized. It occurs in basaltic rocks.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, white, reddish, yellow, gray.
c. Streak, uncolored.
d. Fracture, conchoidal, uneven or fibrous.
e. Transparent, translucent.

3. *Chem.* Before blowpipe it whitens, becoming opaque, and fuses. Gelatinizes with acids.

4. *Diag.* Sometimes resembles Stilbite, but differs in cleavage and lustre.

5. *Obs.* This mineral is found at Nova Scotia and Bergen Hill, N. J.

It belongs to the Zeolite family and is named from Natron (Sodium), which is one of its constituents.

AMPHIBOLE.. { The Base and Silicic Acid are variable.

A Silicate of Lime, Magnesium, Iron, Sodium or Potassium.

Monoclinic System.

H. 5–6.5. Sp. Gr. 3.

1. *Occ.* Its crystal is the inclined rhombic prism. In its varieties it is found columnar. Crystallizes lamellar and fibrous.

2. *Phys.* *a.* Lustre, vitreous or pearly on cleavage faces; silky in the fibrous varieties.
b. Color, from colorless to black, through green.
c. Streak, white.
d. Fracture, uneven.
e. Cleavage, often very perfect.

3. *Chem.* Fusible more or less easily, according to the variety.

4. *Diag.* Amphibole and Pyroxene are much alike and difficult to distinguish. If massive there is no possible distinction. The crystals are easily distinguished by their form; granular masses by measurement of the cleavage and angles.

5. *Obs.* Amphibole is a common mineral. It is known according to composition under several varieties.

(1) The white varieties are called Tremolite; they contain Lime and Magnesia. It occurs in crystalline masses.

(2) The green varieties are called Actinolite. They contain iron, with lime and magnesia.

(3) The black and dark-green varieties are called Hornblende, which is of volcanic origin and usually lamellar. It often replaces mica in granite, forming Syenite.

(4) Asbestus is the result of the decomposition of Amphibole or Pyroxene; even chemical analysis will not always determine which.

It is found in capillary crystals, fibrous and silky. In narrow seams with a satin lustre it is called Amianthus.

Asbestus is the only variety of Amphibole used in the arts. Its fibres are woven into cloth, which resists the action of fire.

The mineral is also used to line safes; the ancients used it for napkins and for the wicks of lamps in their temples.

Amphibole is found abundantly in all its varieties in the U. S. Chester and Brighton, Mass., and Thomaston, Me., are New England localities.

EPIDOTE.. { Lime, 16 – 30.
Alumina, 14 – 28.
Iron, 7 – 17.
Silicic Acid, 36 – 57.

Calcium, Aluminum and Iron Silicate.

Monoclinic System.

H. 6 – 7. Sp. Gr. 3.2 – 3.5.

1. *Occ.* Crystallizes in oblique rhombic prisms. Also occurs massive and in fibrous, granular, or compact aggregates.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, green, yellow or gray.

c. Streak, uncolored.

d. Translucent, opaque.

e. Fracture, conchoidal, uneven.

3. *Chem.* Before blowpipe fuses on the edges with intumescence but does not liquefy. Partially soluble in acids.

4. *Diag.* Ordinary epidote is distinguished at once by its yellowish-green color.

It is distinguished from Pyroxene by its color and by the want of symmetry in its crystrals; from Amphibole and Cyanite by its single cleavage.

5. *Obs.* This mineral has several varieties. A special species is often made of the white variety, which is called Zoisite; it is not probably the same substance as Epidote.

Thulite is a rose variety, which is very rare. Piedmontite has a violet color due to the presence of Manganese. Epidote is found at Chester, Goshen, and elsewhere in Massachusetts, Haddam, Conn., and in New York.

SERPENTINE.. $\begin{cases} \text{Magnesia, 43.} \\ \text{Silicic Acid, 44.} \\ \text{Water, 13.} \end{cases}$

Magnesium Silicate (hydrous).

Orthorhombic System.

H. 3–4. Sp. Gr. 2.5.

1. *Occ.* Is seldom found in crystals except as pseudomorphs of other minerals. Usually compact, sometimes granular or fibrous. Forms independent rocks. It is probably the product of metamorphosis.

2. *Phys.* *a.* Lustre, resinous, oily.
b. Color, dark to light green, sometimes red.
c. Streak, white and shining.
d. Transluc. in thin splinters, opaque.
e. Its feel is unctuous.

3. *Chem.* It is fusible only on the edges with difficulty. With acids it effervesces and gelatinizes.

4. *Diag.* Readily distinguished by its rich, oily color, its sectility and low specific gravity.

5. *Obs.* The right of Serpentine to the character of an independent mineral is open to doubt, as it appears to be only a pseudomorph of other minerals.

The dark green variety is called Precious Serpentine, and is used as a gem.

The fibrous variety is known as Schiller Asbestus. Marmolite is a foliated variety.

Serpentine often occurs in limestone, forming the beautiful Verd-Antique marble, which has been mined at Milford, Conn. Serpentine is found at Newburyport and Westfield, Mass., and elsewhere.

CHRYSOLITE.. { Magnesia, 50. Iron, 9. Silicic Acid, 41.

Magnesium and Iron Silicate.

Orthorhombic System.

H. 6–7. Sp. Gr. 3–4.

1. *Occ.* It crystallizes as a right rhombic prism. The crystals are usually columnar and imbedded. It also occurs massive and disseminated through basalt and lavas.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, green.
c. Streak, colorless.
d. Fracture, conchoidal.
e. Transparent, translucent, opaque.

3. *Chem.* The clear varieties whiten but do not fuse. The dark varieties fuse with difficulty to a magnetic globule. All varieties are decomposed by sulphuric acid.

4. *Diag.* Resembles green quartz and beryl, but is distinguished from them by its gangue.

5. *Obs.* It is sometimes used as a gem but is little valued.

It occurs in New Hampshire and elsewhere.

Chrysolite is doubtless a purely igneous product. It is also called Olivine when massive.

IOLITE.. { Magnesia, 9. Iron, 8. Alumina, 34. Silicic Acid, 49.

Magnesium, Iron and Aluminum Silicate.

Orthorhombic System.

H. 7–7.5. Sp. Gr. 2.6.

1. *Occ.* Its crystals are right rhombic prisms, usually hexagonal, columnar. Also occurs massive and disseminated.

2. *Phys.* *a.* Lustre, vitreous; in fracture, resinous.
b. Color, white, bluish-gray, brownish.
c. Streak, colorless.

d. Fracture, uneven.

e. Transparent, translucent. Beautiful trichroism.

3. *Chem.* Fuses with difficulty. Partially decomposed by acids.

4. *Diag.* Differs from blue quartz in fusing on edges.

5. *Obs.* This mineral has been found in large crystals at Haddam, Conn.; it also occurs in gneiss at Brimfield, Mass.

It is sometimes used as an ornament. When cut, it shows three different shades of color in different directions (trichroism).

CHLORITE.. { Magnesia, 15. Alumina, 20. Iron, 27. Silicic Acid, 26. Water, 12.

Magnesium, Aluminum and Iron Silicate (hydrous).

Hexagonal System.

H. 1–2. Sp. Gr. 2.8–3.

1. *Occ.* Occurs in dark olive-green masses with a granular structure. Crystallizes rarely in hexagonal prisms.

2. *Phys.* *a.* Lustre, pearly to metallic.

b. Color, green, more or less dark.

c. Streak, white or greenish. Touch is greasy, but less so than Talc.

3. *Chem.* Whitens, exfoliates and fuses with difficulty. Soluble in sulphuric acid.

4. *Diag.* Known by its olive-green color and granular structure.

5. *Obs.* It is frequently found in thin plates or scales covering other minerals, as Quartz and Feldspar. A variety is called Ripidolite. Sometimes called Prochlorite. Common.

BIOTITE.. { Alumina, Magnesia, Iron, Silicic Acid } Variable.

Aluminum, Magnesium and Iron Silicate.

Hexagonal System.

H. 2.5–3. Sp. Gr. 2.7–3.

1. *Occ.* It occurs in granite, gneiss, and basalt. Found in hexagonal plates.

2. *Phys.* *a.* Lustre, splendent, or pearly.
b. Green to black.
c. Transparent, transluc. to opaque.
d. Streak, colorless. Splits in thin laminæ.

3. *Chem.* Fuses with difficulty. Decomposed by sulphuric acid.

4. *Diag.* Forms nearly a right prism, while Muscovite leans at an angle of nearly 25°.

5. *Obs.* This mineral should strictly be classed in the Trimetric system. Its axis inclines at an angle of 4 or 5°. This variation is so little it has been classed as above. Most of the dark micas are Biotite.

Found at Vesuvius, Greenwood Furnace, N. Y., and elsewhere.

STAUROLITE.. { Magnesia, 3.
Alumina, 52.
Iron, 16.
Silicic Acid, 29. }

Magnesium, Aluminum and Iron Silicate.

Orthorhombic System.

H. 7.-7.5. Sp. Gr. 3.4-3.8.

1. *Occ.* Crystallizes in right rhombic six-sided prisms. Commonly in the form of a cross. Hence its name from the Greek *σταυρός*, a cross. Never massive.

2. *Phys.* *a.* Lustre, vitreous or earthy.
b. Color, dark reddish-brown to black.
c. Translucent, opaque.
d. Streak, colorless or grayish.

3. *Chem.* Darkens before blowpipe but does not fuse. Insoluble in acids.

4. *Diag.* Distinguished from Tourmaline and Garnet by its color and form.

5. *Obs.* It is usually associated with Cyanite. Found at Windham, Me., Chesterfield, Mass., and elsewhere. Generally occurs in Mica Schist and Gneiss. Sometimes called Staurotide.

TOURMALINE.. { The Base and Silicic Acid are variable. }

Boron, Aluminum and Iron Silicate.

Hexagonal System.

H. 7.-7.5. Sp. Gr. 3.

1. *Occ.* Usually crystallizes in prisms terminated by a low pyramid. The prisms are often triangular in form, with the sides deeply furrowed.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, black, brown, blue, green and red.
c. Sometimes colorless.
d. Streak, uncolored. Very brittle.

3. *Chem.* Mostly infusible. Not acted on by acids.

4. *Diag.* The dark varieties are distinguished by their color, form and absence of cleavage. The red, blue and green varieties may be distinguished by the prismatic sides, which are always 3 or a multiple of 3.

5. *Obs.* Tourmalines occur in granite, gneiss, mica slate and limestone. The finer colored varieties are gems of great value. Red Tourmaline is called Rubellite, and the blue variety, Indicolite. Fine crystals of Rubellite and Indicolite have been obtained at Paris, Me., and Goshen, Mass.

This mineral may contain sodium, potassium, calcium or magnesium in variable quantities.

MUSCOVITE .. { The Base and Silicic Acid are variable.

Potassium, Aluminum and Iron Silicate.

Orthorhombic System.

H. 2–2.5 Sp. Gr. 3.

1. *Occ.* The micas have been found in both the older and more recent plutonic rocks. This class of minerals is distinguished by a remarkable basal cleavage, to a degree not known in any other mineral.

Muscovite crystallizes in oblique rhombic prisms,

with the acute angles replaced. Usually occurs in thin foliated masses, or scales.

2. *Phys.* *a.* Lustre, pearly.
b. Transparent to translucent.
c. Tough, elastic.

3. *Chem.* Whitens and fuses with difficulty. Not affected by acids.

4. *Diag.* Its elasticity distinguishes it from Talc and Gypsum. The inclination of the axes distinguishes it from Biotite. The inclination in Biotite is 5°, in Muscovite 45° to 75°.

5. *Obs.* Mica is one of the constituents of Granite, Gneiss, and Mica Schist.

Transparent plates are found two to three feet in diameter. Used in Russia instead of glass. Generally used for the fronts of stoves and lanterns.

Found abundantly in the United States. Best localities are in New Hampshire. Best known as Common Mica.

LEPIDOLITE.. { Base and Silicic Acid are variable.

Potassium, Lithium, Aluminum and Iron Silicate.

Orthorhombic System.

H. 3-4. Sp. Gr. 3.

1. *Occ.* It crystallizes in right rhombic prisms. It is also found in masses of aggregated scales.

2. *Phys.* *a.* Lustre, pearly.
b. Color, rose-red, lilac, gray, white or yellow.
c. Translucent, has a brilliant play of colors.

3. *Chem.* Fuses with intumescence. Colors flame red. Imperfectly soluble.

4. *Diag.* Distinguished in general by its purplish color.

5. *Obs.* Some varieties contain in addition to the above elements, Manganese, Fluorine, Sodium and Lime. It is frequently associated with the fluorides (Topaz, Apatite, Tourmaline). It occurs with Albite at Chesterfield, Mass. It is found in large quantities at Paris, Hebron and Auburn, Me.

PETALITE.. { Lithia, 4. Soda, 2. Alumina, 20. Silicic Acid, 74.

Lithium, Sodium and Aluminum Silicate.

Monoclinic System.

H. 6–6.5. Sp. Gr. 2.4.

1. *Occ.* Its crystals, inclined rhombic prisms, are exceedingly rare. Generally found lamellar, massive.

2. *Phys.* *a.* Lustre, pearly on base, elsewhere vitreous.
b. Color, white and gray, tinged red or green.
c. Streak, colorless.
d. Translucent in thin plates, opaque.

3. *Chem.* Phosphoresces when gently heated. Fuses on edges with difficulty, tingeing flame red from the Lithia. Is not attacked by acids.

4. *Diag.* Its Lithia reaction allies it to Spodumene, but its density is much higher and its fusibility much easier.

5. *Obs.* It is a very rare mineral, found at Bolton, Mass., and in Sweden. The variety Castorite comes from Elba.

GARNET.. { Composition varies with the varieties.

Isometric System.

H. 6.5–7.5. Sp. Gr. 3–4.

1. *Occ.* Generally found crystallized in rhombic dodecahedrons; sometimes in granular masses. It is often associated with limestones or calcite.

2. *Phys.* *a.* Lustre, vitreous to resinous.
b. Color, ruby-red, brown or black.
c. Transparent, translucent, opaque.
d. Streak white. Cleavage indistinct. Brittle.

3. *Chem.* Most varieties are fusible and more or less soluble in acids.

4. *Diag.* Distinguished in general by its dodecahedral form and its vitreous lustre.

5. *Varieties.* Garnet is a compound of the silicates of alumina, lime, iron and manganese. The colors arise from these various combinations.

(1) Pyrope or Bohemian Garnet. Color red. Transparent to translucent. Crystals rounded at the edges.

(2) Almondite. It is called the Oriental Garnet. Has a fine deep-red color, and is used as an ornament. Common Garnet has a brownish-red color, and may be classed here.

(3) Grossularite is white, yellow or brown.

(4) Spessartite. Hyacinth-red, violet or brownish red.

(5) Andradite. Color various shades — topaz-yellow, apple-green, brownish red, brown or black. Melanite is a black garnet and is of volcanic origin.

6. *Obs.* The varieties of Garnet are not easily distinguished except by chemical reactions. It is a very common mineral, and is found abundantly in various parts of the U. S. The finer varieties are used for gems.

Massive Garnet has been extensively mined in Maine as a substitute for emery. The work is at present abandoned.

NITRE.. { Potassa, 47. Nitric Acid, 53.

Potassium Nitrate.

Orthorhombic System.

H. 2. Sp. Gr. 2.

1. *Occ.* Its primitive form is the right rhombic prism. It generally occurs in thin crusts or needle-form crystals in caverns or on old walls.

2. *Phys.* *a.* Lustre, vitreous.
b. Color, usually white.
c. Streak, white.
d. Transparent. Taste, cooling and saline.

3. *Chem.* Deflagrates and colors the flame violet. Dissolves in one-half its weight of warm water.

4. *Diag.* Distinguished by its taste and its vivid deflagration on a live coal.

5. *Obs.* It is the saltpetre of commerce. It is found in caves along the Mississippi Valley, and other limestone regions. It is found abundantly in the soils of some parts of Spain, Egypt and Russia.

SMALTITE.. { Iron, 9. Nickel, 10. Cobalt, 9. Arsenic Acid, 72.

Iron, Nickel and Cobalt Arsenate.

Isometric System.

H. 5.5–6. Sp. Gr. 6.4.–7.2.

1. *Occ.* Occurs in crystals, generally in cubes. Sometimes massive.

2. *Phys.* *a.* Lustre, metallic.
b. Color, silver-white or grayish.
c. Fracture, granular and uneven.
d. Streak, grayish black.

3. *Chem.* Fuses readily and yields arsenic.

4. *Diag.* Distinguished from arsenopyrite by its crystalline form.

5. *Obs.* It is found at Chatham, Conn., and is used in making smalt. Hence its name.

WULFENITE.. { Lead Oxide, 62. Molybdic Acid, 38.

Lead Molybdate.

Tetragonal System.

H. 2.8. Sp. Gr. 6–7.

1. *Occ.* Crystals usually tabular, sometimes octahedral.

It also occurs in crystalline masses, seldom compact.

2. *Phys.* *a.* Lustre, resinous, adamantine.
b. Color, yellow.
c. Streak, white.
d. Translucent, opaque.

3. *Chem.* Before blowpipe decrepitates and fuses, yielding lead globule.

Decomposed on evaporation in chlorhydric acid.

4. *Diag.* Is distinguished by its blowpipe reaction.

5. *Obs.* This mineral occurs sparingly at Southampton, Mass., and in fine crystals at Phœnixville, Penn.

BORACITE.. { Magnesia, 30. Boracic Acid, 70.

Magnesium Borate.

Isometric System.

H. 7 in crystals; 4 massive. Sp. Gr. 3.

1. *Occ.* Usually crystallizes in cubes with alternate angles replaced.

2. *Phys.* *a.* Lustre is vitreous.
b. Colorless generally.
c. Streak, white.
d. Transparent, transluc. or opaque.

3. *Chem.* Fuses with intumescence. Soluble in acids with effervescence.

4. *Diag.* Distinguished by its form and hardness.

5. *Obs.* Associated with gypsum and common salt.

SUCCINITE.. { Carbon, 80. Water, 20.

A mineral resin.

Does not crystallize.

H. 2. Sp. Gr. 1.

1. *Occ.* It is found in rounded masses, usually of small size and frequently contains insects.

2. *Phys.* *a.* Lustre, resinous.
b. Color, yellow or brown.
c. Streak, white.
d. Fracture, perfectly conchoidal.
e. Transparent, translucent.
f. Negatively electric by friction.

3. *Chem.* Fusible. Burns with a clear flame and agreable smell.

4. *Diag.* It is easily recognized by its color, low specific gravity, and softness.

5. *Obs.* This mineral is a fossil vegetable resin. It occurs on the Baltic coast, and in the United States at Martha's Vineyard, and Cape Sable.

It is the ἤλεκτρον of the Greeks and gave the name of electricity to science, as this agent was first noticed in amber.

It is used for ornaments, and is the basis of an excellent varnish. The specimens containing insects are much prized, as it is supposed that these insects lived before the creation of man. Its usual name is Amber.

CHAPTER X.

HISTORY OF ROCK FORMATIONS.

FORMATION OF THE EARTH.

According to the Nebular Hypothesis, our earth was once a collection of gases. From its gaseous condition it cooled to a liquid state and assumed a spherical form, in obedience to the same laws which round the rain-drop.

In its dense atmosphere were contained the gases of our present atmosphere and all the oxygen and carbon which are now locked in the rock and coal beds of the earth's crust. In it also were suspended vast quantities of mineral matter vaporized by the fierce heat, and all the water now on the earth, in the condition of superheated steam.

This dense air rested in an ocean of liquid fire.

Ages passed, and the earth, cooled by radiation, began to show on its surface patches of solid substance which gradually extended and formed a thin crust over the entire exterior.

The earth had now ceased to be luminous; and as the cooling process continued the vapor became condensed and fell upon the surface as rain. Changed again to vapor by the heat, it again ascended only to fall and repeat the process. By this means the earth was cooled much more rapidly.

As the crust thickened it shrunk; and by the tremendous pressure thus induced it was twisted and rent into folds, volcanic peaks and yawning fissures.

The crust was not yet sufficiently firm to resist the pressure of the heated gases and liquids. From this cause terrific convulsions took place. At length, however, as the cooling went on, the heat was not sufficient to vaporize the water as it fell, and the earth became covered with a boiling, muddy, shallow sea, surging from pole to pole. As there was no dry land, a constant trade wind must have swept over this primitive ocean. Such, Astronomy teaches us, was the probable origin of our globe. As soon as the formation of the crust began, Geology steps in to explain subsequent phenomena. From that time we find that a regular succession of progressive revolutions has taken place, which gradually has fitted the earth for the introduction of life.

It is with these changes that Geology has to deal.

Geology is the history of the earth's crust, as taught by its rocks and fossils.

By a fossil we mean any body, or the traces of the existence of any body, whether animal or vegetable, which has been buried in the earth by natural causes. The fossils show us the former life, both animal and vegetable, which existed upon the surface of the earth or in the waters.

The crust of the earth is constantly increasing in thickness, and the internal convulsions still continue producing volcanoes and earthquakes.

Only about ten miles of the crust is open to the investigations of geology, although the present thickness is estimated to be nearly fifty miles.

GEOLOGICAL DIVISIONS.

The first land which appeared above the surface of the boiling ocean was somewhat in the form of V; it extended from the great lakes northeast to Labrador, and northwest to the Arctic Ocean.

This land, unillumined by the sun and swept by fearful tempests, was, according to most geologists, destitute of life. The age in which it was formed has therefore been called Azoic Time (without life).

Following this we have successive stages in the development of life on the globe.

The history of the crust of the earth is divided into three grand eras, the Paleozöic Time (ancient life), the Mesozoic Time (middle life), and the Cenozoic Time (recent life).

Under these are classified those ages which resemble each other in their dominant types of life.

Time Ratios.—The duration of the Paleozoic, Mesozoic and Cenozoic Ages may be relatively expressed by the ratio 14 : 4 : 3.

The following table will exhibit the geological divisions and subdivisions and the rocks characteristic of each period:—

Geological Eras.	Geological Ages.		Periods.	Characteristic Formations.
I. Cenozoic Time..... (Tertiary Rocks.)	Mammalian Age. (Mammals.)	Post Tertiary.	Terrace.	Elevation of the Continent. Terrace formation.
			Champlain.	Depression of the Continent. Alluvial deposits.
			Glacial.	Ice Period. Drift deposits.
		Tertiary.	Pliocene. (Eu.)	The Tertiary beds consist of Sand, Clay, Slate, Limestone, Marl and Sandstone.
			Miocene. (Eu.)	
			Eocene. (Eu.)	
II. Mesozoic Time..... (Secondary Rocks.)	Reptilian Age .... (Reptiles.)		Cretaceous.	Chalk.
			Jurassic. (Eu.)	Sandstone.
			Triassic. (Eu.)	"New Red Sandstone," Freestone, "Brown Stone."
III. Palæozoic Time.... (Primary Rocks.)	1. Carboniferous Age....... (Coal Plants.)		Permian.	Limestone.
			Carboniferous.	Stratified rocks of all kinds.
			Subcarboniferous.	Conglomerate, Sandstone, Limestone.
	2. Devonian Age .... Or Old Red Sandstone Period. (Fishes.)		Chemung.	Shale and Sandstone.
			Hamilton.	Soft Shale, Shaly Sandstone, Slate.
			Upper Helderberg.	Corniferous Limestone.
			Oriskany.	Sandstone.
	3. Silurian Age. (Mollusks.)	Upper Silurian.	Lower Helderberg.	Limestone.
			Salina.	Shales, Marl.
			Niagara.	Limestone (Dolomite).
		Lower Silurian.	Hudson.	Clay and Shales with Marl.
			Trenton.	Limestone.
			Potsdam.	Sandstone, Limestone.
IV. Azoic Time (not recognized by Lyell)				Granite, Gneiss.

PROGRESS IN DEVELOPMENT.

During the successive ages and periods enumerated in the table, a gradual progressive movement can be traced, not alone in geographical formation, but also in the life upon the earth.

Let us briefly follow these changes from the Azoic Time up to the age of man.

I. PALEOZOIC TIME.. { 1. Silurian Age. 2. Devonian Age. 3. Carboniferous Age.

1. *The Silurian Age.*

Age of Mollusks.

Geography. The Rocky and Appalachian Mountains had begun to rise. Between them was a shallow, muddy ocean. The Green Mountains appeared and sunk again. The St. Lawrence River had assumed nearly its present form. The Hudson and Lake Champlain were begun.

Life. The era was filled with Mollusks, whose shells, deposited on the bottom, formed the limestone deposits of this age.

Sea mosses were the only plants; no life existed on the land.

Remarks. Sunlight first appeared in this age. The climate was everywhere tropical, the temperature uniform.

2. *The Devonian Age.*

Age of Fishes.

Geography. The Silurian sea still retires south. Its border was near the southern boundary of N. Y.

The sea still sweeps through the valley of the Mississippi to the Arctic Ocean.

Life. Fishes with a bony armor abound in the waters, and coral insects are busily building up the continent.

Flags and rushes abound along the rivers, while ferns and a few cone-bearing trees are found on the land.

Remarks. The old red sandstone is the prevalent rock of this age. Vast coral beds were formed.

The temperature was still uniform and tropical.

3. *The Carboniferous Age.*

Geography. The retreat of the coast line south and west continues. The Rocky Mountains exist only as detached islands; great changes of level are taking place in the Appalachian Mountains. The coal area sinks and rises many times, forming layers of limestone between the strata of coal. The Southern States emerge and the Mississippi Valley exists as a vast marsh.

Life. Fishes still abound, some insects, and a few reptiles foreshadow the life of the succeeding age.

The air, filled with all the carbonic acid now locked in the coal beds, the tropical climate and marshy surface, gave rise to a luxuriant vegetation, by which the air was freed from carbonic acid and fitted for air-breathing animals.

The plants of this age are of a huge size and principally of an endogenous growth.

Remarks. The climate was tropical from pole

to pole throughout all Paleozoic Time. The close of this age was marked by great convulsions, which neither animal nor vegetable life survived.

The Appalachians were thrown up far higher than at present; ruptures and upheavals took place in the coal measures; and much of the coal gave up its bitumen and became anthracite.

Nine-tenths of the rocks of the earth's crust were now in existence; many of these beds were crystallized and stored with mines of gold, iron, lead and tin.

II. Mesozoic Time.

Reptilian Age.

Geography. New England was now a peninsula, the Connecticut Valley an arm of the sea, the Gulf of Mexico extended to the Arctic Ocean, while great upheavals were taking place all over the continent. The Sierra Nevada and Sierra Madre were uplifted and the Atlantic seacoast was probably 80 to 100 miles farther to the east.

Life. Most of the old forms have disappeared. Reptiles everywhere abound. Some are of enormous size, as the Ichthyosaurus, Plesiosaurus, Pterodactyl.

Ferns, reeds and pines are the typical land plants; exogens are added to the endogens of the Carboniferous Age.

Remarks. Rock salt deposits took place in Europe during the Jurassic Period; in New York during the Salina period. The gold-bearing rocks

of California are of this age. The Cretaceous Period is marked by the abundance of chalk, as in England and France. The climate is tropical to 60° of latitude.

The close of this age was also a period of convulsions. All former types of life, animal and vegetable, disappear, and the reign of reptiles is closed.

III. Cenozoic Time.

Mammalian Age.

Geography. By the upheavals at the close of the Mesozoic Age the Central Sea was divided near the mouth of the Ohio River. During the Champlain Period the land sunk again, but emerged during the Terrace Epoch to nearly its present form.

Life. Numerous animals are found on the land, while the marine monsters of the preceding age have disappeared. Birds, insects and quadrupeds abound. Mammals, the highest type of animal life, have commenced their sway; and, later in the age, man appears upon the earth prepared for him by all these ages of change.

The present forms of vegetation gradually cover the earth during the Champlain and Terrace Epochs.

Remarks. The Glacial Epoch or Drift Period, was characterized by arctic cold, the extinction of life, and the moving of vast ice fields from North to South, over the whole of North America. Traces of this movement are seen in the boulders scattered over the surface, in the striation of the surface rocks, and in the graceful rounding of our hills on

the northern slopes. The large rivers seem to have had each an independent glacier.

During the Champlain Epoch these ice masses disappeared; the climate became warmer, and the continent was again submerged for the last time; only the mountain tops remained above the water.

The Terrace Epoch witnessed the final emerging of the land. Several pauses took place in this movement, and thus terraces were formed, as in the valley of the Connecticut. Mammals again appeared, some of them of enormous size, as the Mammoth, Mastodon, Megatherium, and Cave Bear. Side by side with their fossil remains are found the bones of man.

The earth is not yet complete; changes similar to those discussed above, are constantly going on. Some portions are sinking, others rising. What the future of our globe may be can only be conjectured.

CHAPTER XI.

DESCRIPTION OF ROCKS.

The several substances which form the materials of the earth's crust are called rocks. The component parts of rocks are always minerals.

Most rocks are made up of two or more different minerals and are therefore called *Composite Rocks*. Some however, as limestone, consist of a

single mineral only and are accordingly termed *Simple Rocks*.

The number of the principal minerals in the rocks of the earth is relatively very small.

They are as follows: Quartz, Feldspar, Mica, Hornblende, Pyroxene, Calcite and Dolomite. The following occur less frequently: Chlorite, Talc, Chrysolite, Gypsum, Coal and Iron ores.

The number of accessory ingredients is much greater, as is seen under Mineralogy.

The following table will exhibit a classification of the rocks. Besides those mentioned in the table, there are many simple rocks which form a very small portion of the earth's crust. They are therefore omitted here but are nearly all described under the minerals :—

CLASSIFICATION OF ROCKS. (LYELL.)

I. AQUEOUS ROCKS.... Also called Stratified, Sedimentary and Fossiliferous.	1. Siliceous Rocks.	Sandstone. Flint.		
	2. Argillaceous Rocks.	Clay. Shale. Marl.		
	3. Calcareous Rocks.	Chalk. Limestone. Marble. Oolite. Gypsum.		
II. VOLCANIC ROCKS... Usually unstratified. (Formed on the exterior of the earth.	Divided by composition into	Basaltic. (Poor in Silica.) — Basalt. Melaphyre. Greenstone. Trachytic. (Rich in Silica.) — Obsidian. Phenolite or Clinkstone.	Divided by structure into	Porphyry. Amygdaloid. Lava. Pumice, Scoriæ. Volcanic Tufa. Wacke. Agglomerate. Laterite.
III. PLUTONIC ROCKS.... Unstratified. (Formed in the interior of the earth.)	Granite. Syenite.			
IV. METAMORPHIC ROCKS. Or Stratified Crystalline Schists.	Gneiss, Mica Schist, Hornblende Schist, Talcose Slate, Clay Slate, Chlorite Schist,	Schist or Slate.		
	Serpentine. Steatite. Metamorphic Limestone. Quartzite.			

I. *AQUEOUS ROCKS.*

These rocks are also called Sedimentary and Fossiliferous. They cover a larger part of the earth's surface than any others. They are mostly mechanical deposits, but are in part of chemical, and some of them, as the limestones, of organic origin.

They are stratified and contain fossils. Shells and corals are the most abundant. Besides these we find the bones, scales, and teeth of fishes, fragments of wood, impressions of leaves and other organic substances. Fossil shell of forms such as now abound in the sea, are met with far inland, at great elevations above the surface, and at great depths below it. It is therefore concluded that these strata were deposited at the bottom of the ocean.

Aqueous Rocks may be divided into three general classes: —

1. Siliceous and Arenaceous Rocks, as sandstone.
2. Argillaceous Rocks, clay, slate, etc.
3. Calcareous Rocks, the limestone.

1. Siliceous or Arenaceous Rocks.

Sandstone. This is an aggregate of grains of sand consisting almost entirely of Silica. It has various names according to structure, composition, and age: as, globular, argillaceous, talcose, old red, new red, etc.

In micaceous sandstone, mica is very abundant.

When sandstone is course grained it is called *grit;* if the grains are large and like pebbles, it becomes a *pudding-stone*, or *conglomerate.*

Freestone is a red sandstone.

Flint is nearly pure Silica, and is of organic origin. It occurs in chalk formations in the form of nodules.

2. Argillaceous Rocks.

Clay. Clay is a mixture of Silica with about 25% of Alumina. Its composition is variable however.

The purest clay is Kaolin or porcelain clay.

Shale is a more solid form of clay, but becomes plastic in water.

Clay-stone is a compact, solid mass, *not slaty.*

Clay-slate is the result of metamorphosis, and therefore will be considered under the Metamorphic Rocks.

We may also include here the Marls, which are closely allied to the Clays, standing between them and the Limestones. They are earthy compounds of clay and carbonate of lime, which crumble on exposure to the air.

3. Calcareous Rocks.

The Limestones.

This division comprehends those rocks composed chiefly of lime and carbonic acid.

Chalk is sometimes pure lime carbonate. It occurs in extensive beds in England, and probably extends across the channel into France, as it is well known that in the vicinity of Paris chalk is found at a considerable distance from the surface.

Limestone. Some limestones are made up entirely of shells and coral. Most marbles belong to the aqueous rock, only the finest — the statuary marble which is crystallized — being of the metamorphic division.

Gypsum is a rock composed of lime, sulphuric acid and water; it is further considered under minerals.

Oölite is a limestone composed of numerous small egg-like grains, each of which has a grain of sand as its centre.

The limestones are much used in building. Some are burned to quicklime. The marbles are used for ornaments and ordinary building.

II. *VOLCANIC ROCKS* (Trap).

These rocks, as well as the Plutonic, are sometimes known as Igneous Rocks. They have been produced by ejection (in a state of fusion) from the interior of the earth, through fissures or craters of volcanoes. They are, for the most part, unstratified and devoid of fossils.

Columnar structure is a characteristic of Trap Rocks. This is seen in the Giant's Causeway in Ireland, and at the island of Staffa. The columns are prisms of from three to twelve angles, often divided transversely at nearly equal distances. Columnar Trap has consolidated from a fluid state, and the prisms are said to be always at right angles to the cooling surfaces. Trap Rock frequently occurs in dikes, penetrating other rocks sometimes for a distance of several miles.

There are two principal families of trappean rocks: the Basalts and the Trachytes.

1. Basaltic Rocks.

The Basalts contain less than 50% of Silica, and are heavier than the Trachytes.

Basalt. This, the type of the Basaltic Rocks, is a rock very compact, amorphous, and often semi-vitreous in texture, with a perfect conchoidal fracture.

Melaphyre differs from Basalt only in being lighter in color and containing less chrysolite.

Greenstone is a granular mixture of hornblende and feldspar, or of augite and feldspar.

2. Trachytic Rocks.

These are richer in silica than the Basalts.

Obsidian. Trachytic Rocks by fusion form a volcanic glass known as Obsidian, Pitchstone and Pearlstone. The difference between these is caused by different rates of cooling.

Clinkstone or Phenolite. This member of the Trachytic family is distinguished by its fissile structure, its tendency to lamination, and its ring when struck. It is almost entirely composed of feldspar.

These volcanic rocks take different names according to structure.

Porphyry is one of this class. When distinct crystals of one or more minerals are scattered throughout an earthy or compact base, the rock is termed a porphyry. Trachyte is usually porphy-

ritic; we may also have greenstone-porphyry, basalt-porphyry, etc.

Amygdaloid. This is another form of igneous rock, admitting of every variety of composition.

It comprehends any rock in which round or almond-shaped (Greek, ἀμύγδαλον, or almond) nodules of some mineral are scattered throughout a base of trap.

Lava. This term is applied to the melted matter which flows from volcanoes. If it does not reach the surface, but is merely injected into fissures under ground it is called trap.

Pumice is a porous, spongy substance produced by the action of gases on lava.

Tufa. Small angular fragments of pumice and scoriæ, together with small pieces of other rocks ejected from the crater, cohere and form Tufas. Sometimes shells are mingled with them and the whole bound together by a calcareous cement.

Wacke is a name given to a decomposed state of various trap rocks of the basaltic family.

Agglomerate. The sharp angular fragments of any material forming accumulations around a crater are called agglomerate. If worn round by the action of water, they form a conglomerate. If all the fragments are of volcanic rocks, they form a *Volcanic Breccia.*

Laterite. This is a red rock composed of Silicate of Alumina and Oxide of Iron. The "ochre beds" of the Giant's Causeway are Laterite.

III. *PLUTONIC ROCKS.*

These are supposed to have been formed at considerable depths in the earth, while Volcanic Rocks have cooled more rapidly upon or near the surface.

They differ from the Volcanic Rocks in their more crystalline texture, in the absence of Breccia and Cellular cavities, and in never being amygdaloidal.

Plutonic Rocks are Granite and Syenite.

1. GRANITE.

Granite, one of the most widely disseminated of the rocks forming the crust of the earth, is composed of three minerals, quartz, mica and feldspar. These are mixed in varying proportions and the granite is called *quartzose*, *micaceous* or *feldspathic*, according as the quartz, mica, or feldspar predominates.

It is sometimes called the primitive rock, as it seems to be the one which constitutes the basis of the earth's crust. It is not probable, however, that the cooling of the interior lavas will produce granite directly. Therefore, some change must have taken place, and granite has accordingly been called a Metamorphic Rock. We prefer the name of Plutonic, as given by Lyell, because it is indicative of a more complete transformation than the other.

Graphic Granite. A peculiar arrangement of the quartz in an imperfect laminar structure is called Graphic Granite. When a section is made at right angles to the alternate plates of feldspar and

quartz it presents broken angular lines somewhat resembling Hebrew characters.

Porphyritic Granite. Sometimes large crystals of feldspar are found scattered throughout a granite base; this is known as Porphyritic Granite.

Talcose Granite—the Protogine of the French—contains Talc instead of mica.

Granite is the usual rock for tin ores. It also contains veins of other metallic ores, as lead, copper, zinc and bismuth. Emerald, topaz, zircon, garnet, tourmaline, corundum and many other species of minerals, are found in granite.

The quartzose granite is more durable than the feldspathic, and is used in paving streets as well as in building. The feldspathic variety is of great use in the manufacture of porcelain.

2. SYENITE.

Hornblende sometimes replaces the mica, and the rock is then called Syenite. Much of the granite used in building is properly Syenite; the Quincy granite, so called, is of this nature.

Syenite is even more durable than granite proper. Bunker Hill Monument is of this material, also the Boston Custom House, and the Astor House in New York. It takes it name from Cyene in Upper Egypt, where the Egyptians quarried it for building their monuments and temples. This ancient material, however, is only a granite with black mica, and not hornblende, as was supposed.

IV. *METAMORPHIC ROCKS.*

These rocks are stratified and crystalline. They are also known as the Crystalline Schists.

They are wholly devoid of organic remains and contain no distinct fragments of other rocks. They have probably at some time been deposited as sedimentary rocks, and have been changed by the action of heat and water.

Under this head we shall consider the following rocks: —

1. Gneiss,
2. Mica Schist,
3. Hornblende Schist,
4. Talcose Schist,
5. Clay Slate,
6. Chlorite Schist,
7. Serpentine.
8. Steatite.
9. Metamorphic Limestone.
10. Quartzite.

(Items 1–6: Schist or Slate.)

1. Gneiss.

Gneiss has the same composition as granite, but differs from it in being stratified or foliated. It is simply the name given to schistose granite.

Gneiss is found to be of high antiquity; it usually overlies the granites, but is beneath the oldest sedimentary or fossiliferous rocks.

It cleaves readily parallel to its structure. This cleavage occurs where the mica is most abundant. The thin slabs are used for flagging, but when it can be quarried in thicker blocks it is used for building.

At Amherst College some of the buildings are of this material.

2. Mica Slate, or Mica Schist.

This is, next to Gneiss, one of the most abundant of the Metamorphic rocks. Its constituents are the same as those of gneiss, but it has more mica and less feldspar in it. It is used for flagging, for lining furnaces, for scythe stones and whetstones. It is quarried at Chesterfield, Enfield and Norwich, Mass.; also in Connecticut, Rhode Island and Vermont.

3. Hornblende Slate or Schist.

Differs from Mica Slate in having hornblende instead of mica. This makes it more durable and therefore very valuable for flagging.

4. Talcose Schist.

Resembles Mica Slate, but contains talc instead of mica.

5. Clay Slate or Schist.

Mica slate passes by insensible gradations into Clay Slate. This is the material meant when the term slate is used alone. Its colors are bluish, greenish, gray or reddish. Slate is used for roofing, for pencils, drawing slates, &c.

There is a gradual passage from granite to gneiss, from gneiss to mica slate, from mica slate to clay slate.

6. Chlorite Schist.

This is a Metamorphic rock similar to the other slates, but contains the mineral Chlorite.

The slates are the gold rocks of the world, especially the quartzose veins.

7. Serpentine.

This is a dark green rock associated with talcose rocks and with granular limestone. It is a simple rock, and is described under minerals.

8. Steatite or Soapstone.

This associated rock is easily cut by a knife. Its color is usually grayish green. It is used for fire-stones and similar purposes; also to lessen friction in machinery, and for mixing with graphite in the manufacture of crucibles.

9. Crystalline Limestone.

This is the white granular marble used in sculpture. The finest comes from Carrara in Italy.

Most of the limestones, and many of the marbles, are not crystalline, and belong to the aqueous or sedimentary rocks.

Some authorities class all marbles as metamorphic. This is no doubt an error, as many marbles are simply limestone capable of receiving a polish without crystalline structure.

10. Quartzite or Quartz Rock.

There is a further passage by the more or less complete absence of the feldspar, into a *Micaceous*

Quartz Rock, and by a more or less complete absence of the mica from this to a pure *massive quartz rock* also called *Quartzite.* It is a very firmly consolidated sandstone composed of quartz sand, cemented together by heat.

Its colors are light gray, reddish or bluish. Buhrstone, used for millstones, is a quartzite containing cellules, which give it a very rough surface; hence its peculiar value.

The best Buhrstone comes from France, near Paris. It is of the Tertiary formation, and, therefore, of much more recent origin than the quartzite above described.

The Itacolumite of Brazil and many gold regions, is a Micaceous Quartzite.

Quartzite is used in the manufacture of glass and sandpaper, and for sawing marble.

In the shape of cobble stones it is a common paving material.

In addition to the rocks thus classified we may mention Coal and Ice, which are true simple rocks.

Coal is fully described in another part of this work as a mineral.

V. *ICE.*

This simple rock in the high latitudes occurs in large masses and forms a considerable part of the solid crust of the earth. It is also familiar to us in the colder seasons, but usually exists in the warmer countries in its allotropic form of water.

As the snow accumulates in the polar regions, its weight tends to consolidate it into a granular,

stratified ice. As the mass increases, its weight, with other causes, gives it a slow motion, and it becomes a glacier. Glaciers were at one time moving all over North America as well as Europe. The formation of soil is due in a large degree to the abrasions caused by glaciers.

The immense masses of ice which cover Greenland are in motion toward the sea, a very small part in an easterly direction, the rest toward Baffin's Bay. As these masses reach the shore they continue to grate along the rocky bottom like ordinary glaciers long after they have reached the salt water. When finally they reach deeper water its buoyant power breaks off portions from 1000 to 1500 feet in thickness, which float away, bearing with them fragments of rock, fine mud and sand. These ice masses are known as icebergs. As they float into warmer waters they melt rapidly, depositing their burden of earth and stones. The Grand Banks of Newfoundland are formed from such deposits.

CORRIGENDA.

Page 19. For "crumble" read crumbles.
Page 24. For "Cobalite" read Cobaltite.
Page 24. For "Sinmarite" read Linnæite.
Page 49. For "loadstone" read lodestone.
Page 59. For "Chrysophrase" read Chrysoprase.
Page 60. After "fine specimens" insert "of quartz."
Page 61. For "Latin Spar" read Satin Spar.
Page 71. For "grades" read geodes.
Page 82. For "Rhartizite" read Rhætizite.
Page 89. For "infusibility" read fusibility.
Page 113. For "era" read sea.
Pages 119 and 127. Gneiss should not be included in the brace.

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